Department of Electronics & Communication Engineering

Minor Programme in Electronics and Communication Engineering

Minors are coherent sequences of courses taken in addition to the courses required for the Bachelor of Engineering students chosen from a considerable variety of complementary courses under the categories of technical and complementary studies.

Department of Electronics and Communication Engineering, JUIT, Waknaghat proudly offers minor in Electronics and Communication Engineering for all concerned students. This minor program covers the most current theories and practices used in Electronics and Communication Engineering. The program provides a valuable adjunct credential to engineering students pursuing their major degree in various fields. Engineering students from any branch may choose from a considerable variety of complementary courses under the categories of technical and complementary studies offered by Electronics and Communication Engineering Department JUIT, Waknaghat. This minor program is rigorous enough to serve as a introductory credential for students subsequently electing to pursue advanced studies in Electronics and Communication Engineering.

Conditions for Award of Additional Certificate of Minor in Electronics and Communication Engineering

1. Earning of minimum credits, as required for award of Major degree.
2. Earns 20 credits in addition to the credits as specified for the programme in the minor area.
3. Additional 20 credits in a minor discipline could be earned through MOOCs also and may include supporting courses from allied discipline limited to a maximum of 6 credits.
4. Successfully completing the Industrial Internship within the minimum period of 4 years.
5. Completing all the requirements of a degree in the minimum period of years.

Following is the course curriculum outline for proposed Minor programme in Electronics and Communication Engineering, from which subjects worth 20 credits may be chosen by the student:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN							
COURSE CURRICULUM FOR MINOR PROGRAMME(160 +20 CREDITS)							
MINOR IN ELECTRONICS AND COMMUNICATION ENGINEERING							
S. No.	**Semester**	**Name of the Subjects**	**Course Hours**			**Credits**	**Total Hours**
			L	**T**	**P**		
1	3	Digital Electronics & Logic Design	3	1	0	**4**	**4**
2	3	Digital Electronics & Logic Design Lab	0	0	2	**1**	**2**
3	4	Modern Analog and Digital Communication	3	1	0	**4**	**4**
4	5	Microprocessor and Interfacing	3	0	0	**3**	**3**
5	5	Microprocessor and Interfacing Lab	0	0	2	**1**	**2**
6	6	Advance Communication Lab	0	0	2	**1**	**2**
7	6	Wireless and Data communication	3	0	0	**3**	**3**
8	7	Internet of Things	3	0	0	**3**	**3**
					Total	**20**	**23**

* Elective courses from MOOC or NPTEL may be chosen by student (maximum 6 credits) in case course content matches with subjects mentioned above.

Proficiency Programme in Electronics and Communication Engineering

Electronics and Communication Engineering students can choose to either broaden their background or attain in-depth coverage of a particular subject by enrolling in a Proficiency Programme. Proficiency courses are coherent sequences of courses that may be taken in place of regular elective slots required for the B. Tech degree, in the chosen field of proficiency.

Conditions for award of additional certificate of proficiency in Electronics and Communication Engineering

1. Qualify for the award of B. Tech. degree in the minimumperiod.
2. Have passed in minimum of >50% of B. Tech elective subjects taken from Electronics and Communication Engineering Department.
3. Grade Point Average in the elective subjects of (2) is >7.0.
4. Major project has been done in Electronics and Communication Engineering Department with at least 'A' grade
5. CGPA for 195 credits (pre 2018 batch) /160 credits (post 2018 batch) of B. Tech. level is >6.5.

At present Department of Electronics and Communication Engineering JUIT, Waknaghat offers following proficiency programmes:

1. Proficiency in Embedded System
2. Proficiency in Communication Technology
3. Proficiency in Machine Learning
4. Proficiency in Signal Processing
5. Proficiency in Digital Image Processing
6. Proficiency in Microwave and RF Design

The Proficiency programmes offered in aforementioned areas are designed primarily for students of Electronics and Communication Engineering Department, JUIT to experience the engineering approach to the solution of design problems. Students pursuing any of the proficiency courses will be better prepared for careers in Electronics and Communication Engineering. These proficiency courses will provide students with a technical and competitive edge over most traditional Electronics and Communication Engineering undergraduates in the Electronics and Communication Engineering job marketplace

Following are the course curriculum outline for proposed 6 proficiency courses:

1. Proficiency in Embedded Systems:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN								
COURSE CURRICULUM FOR PROFICIENCY PROGRAMME (160 CREDITS)								
PROFICIENCY IN EMBEDDED SYSTEM								
S. No.	**Semester**	**Subject Code**	**Name of the Subjects**	**Course Hours**			**Credits**	**Total Hours**
				L	**T**	**P**		
1	**5**	20B1WEC531	Switching Theory and Logic Design	3	0	0	**3**	**3**
2	**6**	19B1WEC631	Embedded system design	3	0	0	**3**	**3**
3	**7**	18B1WEC744	FPGA based Instrumentation System Design	3	0	0	**3**	**3**
4	**7**	19B1WEC731	Real Time Operating System	3	0	0	**3**	**3**
5	**8**	19B1WEC831	Digital CMOS ICs	3	0	0	**3**	**3**
6	**8**	19B1WEC832	CAD Algorithms for Synthesis of Digital Systems	3	0	0	**3**	**3**

* Elective courses from MOOC or NPTEL may be chosen by student (maximum 6 credits) in case course content matches with subjects mentioned above.

2. Proficiency in Communication Technology:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN								
COURSE CURRICULUM FOR PROFICIENCY PROGRAMME (160 CREDITS)								
PROFICIENCY IN COMMUNICATION TECHNOLOGY								
S. No.	**Semester**	**Subject Code**	**Name of the Subjects**	**Course Hours**			**Credits**	**Total Hours**
				L	**T**	**P**		
1	**5**	18B1WEC535	Communication Engineering	3	0	0	**3**	**3**
2	**6**	18B1WEC633	Optical Communication Systems	3	0	0	**3**	**3**
3	**7**	18B1WEC745	Next Generation Communication Systems	3	0	0	**3**	**3**
4	**7**	18B1WEC736	OFDM and Applications	3	0	0	**3**	**3**
5	**8**	18B1WEC849	Cognitive Radio Networks	3	0	0	**3**	**3**
6	**8**	19B1WEC833	Wireless Communication and Mobile Networks	3	0	0	**3**	**3**

* Elective courses from MOOC or NPTEL may be chosen by student (maximum 6 credits) in case course content matches with subjects mentioned above.

3. Proficiency in Machine Learning:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN								
COURSE CURRICULUM FOR PROFICIENCY PROGRAMME (160 CREDITS)								
PROFICIENCY IN MACHINE LEARNING								
S. No.	**Semester**	**Subject Code**	**Name of the Subjects**	**Course Hours**			**Credits**	**Total Hours**
				L	**T**	**P**		
1	**5**	20B1WEC532	Introduction to Machine Learning	3	0	0	**3**	**3**
2	**6**	19B1WEC632	Machine Learning for Data Analysis	3	0	0	**3**	**3**
3	**7**	19B1WEC732	Pattern Analysis in Machine Intelligence	3	0	0	**3**	**3**
4	**7**	19B1WEC733	Optimisation Techniques	3	0	0	**3**	**3**
5	**8**	18B1WEC838	Artificial Intelligence Techniques	3	0	0	**3**	**3**
6	**8**	18B1WEC851	Soft Computing Techniques	3	0	0	**3**	**3**

* Elective courses from MOOC or NPTEL may be chosen by student (maximum 6 credits) in case course content matches with subjects mentioned above.

4. Proficiency in Signal Processing:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN								
COURSE CURRICULUM FOR PROFICIENCY PROGRAMME (160 CREDITS)								
PROFICIENCY IN SIGNAL PROCESSING								
S. No.	**Semester**	**Subject Code**	**Name of the Subjects**	**Course Hours**			**Credits**	**Total Hours**
				L	**T**	**P**		
1	**5**	19B1WEC531	Statistical Signal Processing	3	0	0	**3**	**3**
2	**6**	18B1WEC631	Digital Filter Design and Applications	3	0	0	**3**	**3**
3	**7**	18B1WEC738	Time Frequency Analysis and Applications	3	0	0	**3**	**3**
4	**7**	19B1WEC734	Wavelets and Applications	3	0	0	**3**	**3**
5	**8**	19B1WEC834	Adaptive Signal Processing and Machine Intelligence	3	0	0	**3**	**3**
6	**8**	19B1WEC835	Bioelectronic Sensors	3	0	0	**3**	**3**

* Elective courses from MOOC or NPTEL may be chosen by student (maximum 6 credits) in case course content matches with subjects mentioned above.

5. Proficiency in Digital Image Processing:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN								
COURSE CURRICULUM FOR PROFICIENCY PROGRAMME (160 CREDITS)								
PROFICIENCY IN DIGITAL IMAGE PROCESSING								
S. No.	Semester	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	5	20B1WEC533	Fundamentals of Digital Image Processing and Applications	3	0	0	3	3
2	6	19B1WEC633	Computer Vision	3	0	0	3	3
3	7	19B1WEC735	Forensic Image Processing	3	0	0	3	3
4	7	18B1WEC847	Medical Image processing	3	0	0	3	3
5	8	19B1WEC836	Applied Medical Signal Processing	3	0	0	3	3
6	8	19B1WEC837	Remote Sensing and Satellite Image Processing	3	0	0	3	3

* Elective courses from MOOC or NPTEL may be chosen by student (maximum 6 credits) in case course content matches with subjects mentioned above.

6. Proficiency in Microwave and RF Design:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN								
COURSE CURRICULUM FOR PROFICIENCY PROGRAMME (160 CREDITS)								
PROFICIENCY IN MICROWAVE AND RF DESIGN								
S. No.	Semester	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	5	19B1WEC532	RF Integrated Circuits	3	0	0	3	3
2	6	19B1WEC634	Fundamentals of Computational Electromagnetics	3	0	0	3	3
3	7	18B1WEC746	Microwave Theory and Techniques	3	0	0	3	3
4	7	18B1WEC742	Antenna and Wave Propagation	3	0	0	3	3
5	8	18B1WEC852	Design of Modern Antennas	3	0	0	3	3
6	8	18B1WEC848	RF Engineering	3	0	0	3	3

* Elective courses from MOOC or NPTEL may be chosen by student (maximum 6 credits) in case course content matches with subjects mentioned above.

Switching Theory and Logic Design

COURSE CODE: COURSE

CREDITS: 3

CORE/ELECTIVE: ELECTIVE L-T-P:

3-0-0

Pre-requisite: None

Course Objectives:

1. To make the students understand the concepts of digital circuits.
2. To design complex digital circuits based on the given requirement.
3. Understand the programming of digital circuits using VHDL.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the basic concepts of digital circuits.	Familiarity
CO-2	Learn about different the basic principles used in the working of digital circuits.	Familiarity
CO-3	Understand various hazards encountered in designing these circuits.	Assessment
CO-4	Learn to write programs using VHDL.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Digital Circuits: Design of combinational circuits, Quine- McCluskey method, sequential machine fundamentals - the need, concept of memory, Flip flops, sequential machine operations, classifications. Switching Circuits. Logic families: TTL, nMOS, CMOS, dynamic CMOS. Logic design using ROMs, PLAs and FPGAs. Case studies	5
2	Design of Synchronous Sequential Circuits: Sequential circuits, Finite state model – Basic definition, capabilities and limitation of finite state machines, state equivalence & machine minimization, simplification of incompletely specified machines, Extraction of maximal compatibles, synthesis & analysis of synchronous sequential circuits.	8
3	Design of Asynchronous Sequential Circuits: Introduction to asynchronous circuits, timing diagram, state diagram & flow tables, types of asynchronous circuits, fundamental mode circuits, pulse mode circuits, state assignment in asynchronous sequential circuits, Synthesis and analysis, ASM charts: Representation of sequential circuits using ASM charts.	8

4	Hazards and Races: Introduction, gate delays, generation of spikes, production of static hazards in combinational networks, elimination of static hazards, design of hazard free combinational networks, hazard free asynchronous circuit design, dynamic hazards, essential hazards, Races and Cycles.	9
5	VHDL/Verilog HDL: Verilog as HDL, Levels of Design Description, Concurrency, Simulation and Synthesis, Functional Verification, System Tasks, Programming Language Interface (PLI), Module, Simulation and Synthesis Tools, Test Benches. Language constructs and conventions: Introduction, Keywords, Identifiers, White Space Characters, Comments, Numbers, Strings, Logic Values, Strengths, Data Types, Scalars and Vectors, Parameters, Memory, Operators, System Tasks, Exercises.	12
Total lectures		42

Suggested Text Book(s):

1. Switching and Finite Automata Theory, ZVI Kohavi, Third Edition, Cambridge University Press.
2. John M Yarbrough : Digital Logic Applications and Design, 2nd Edition, Thomson Education
3. W. I. Fletcher :An Engineering approach to Digital Design , PHI

Suggested Reference Book(s):

1. Digital Systems Design using VHDL – Charles H Roth, CENGAGE Learning.

Other useful resource(s):

1. NPTEL: https://nptel.ac.in/courses/106/105/106105185/
2. Coursera: https://www.coursera.org/learn/digital-systems
3. Swayam: https://swayam.gov.in/nd1_noc19_cs74/preview

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Switching Theory and Logic Design)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	2	2	2	2	2	x	x	x	1	3	3	2.22
CO-2	3	3	3	2	2	3	x	x	x	1	2	3	2.44
CO-3	3	3	2	3	3	2	x	x	x	1	2	3	2.44
CO-4	3	3	2	3	3	2	x	x	x	1	3	2	2.44
Average	3	2.75	2.25	2.5	2.5	2.25	x	x	x	1	2.5	2.75	

Embedded System Design

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite:

None

Course Objectives:

To learn about the embedded system application areas, design challenges, design and development methodology, tools used for embedded system design, embedded system integration and testing.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand various components of embedded system, design challenges and design metrics	Familiarity
CO-2	Learn about embedded system programming through 8051 microcontroller, programming and I/O interfacing	Usage
CO-3	Comprehend RISC architecture, programming of ARM and PIC microcontrollers	Usage
CO-4	Know about embedded system design and development methodology, tools and languages used for embedded system design	Usage
CO-5	Learn about integration and testing of embedded systems	Assessment

Course Contents:

Unit	Contents	Lectures Required
1	Introduction: Embedded systems overview, Classification, Application areas, Design challenges – real-time execution, physical size, power consumption, multirate operation. Design metrics – time-to-market, unit cost, performance.	4
2	Typical Embedded System: Core of the embedded system, Sensors and actuators, Communication interface, Embedded firmware	6
3	8051 Microcontroller: 8051 Architecture, timers and interrupts, Special function registers, Program/ data memory, addressing modes. instruction set, interrupts,	8
4	ARM Processor Fundamentals and Architectures, ARM Instruction Set, PIC Microcontroller and its Architecture.	10
5	Design and Development of Embedded product: Analog Electronic Components, Digital Electronic Components, Electronic design automation tools, Embedded firmware design approaches, Embedded firmware development languages	8

6	Integration and testing of embedded hardware and firmware, Embedded system development environment, Product enclosure design and development, Embedded product development life cycle, Trends in embedded industry	6
Total		42

Suggested Text Book(s):

1. Frank Vahid and Tony Givargis, “Embedded system design: A unified Hardware/Software introduction,”3rd Ed., Wiley 2014
2. Shibu K. V, “Introduction to Embedded Systems,” 2nd Ed., McGraw Hill, 2017

Suggested Reference Book(s):

1. Steve Furber, “ARM System-on-Chip Architecture,” 2nd Ed., Pearson 2012
2. Tim Wilmshurst, “Designing Embedded Systems with PIC Microcontrollers: Principles and Applications,” 2nd Ed., Newnes, 2009
3. Steven F Barrett and Daniel J Pack, “Embedded Systems Design and Applications with the 68HC12 and HCS12,” 1st Ed., Pearson 2012
4. Kenneth Ayala, “The 8051 microcontroller,” 3rd Ed., Thomson, 2005

Other useful resource(s):

NPTEL ONLINE COURSES

1. Embedded Systems: https://nptel.ac.in/courses/108105057/ (Prof. A. Routray, Prof. Rajib Mall, Prof. Amit Patra, IIT Kharagpur)
2. Embedded Systems: https://nptel.ac.in/courses/108102045/ (Prof. Santanu Chaudhary, IIT Delhi)
3. Embedded Systems Design: https://nptel.ac.in/courses/106105159/ (Prof. Anupam Basu ,IIT Kharagpur)

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO (Embedded System Design)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	X	2	1	2	X	X	X	X	X	3	1	0.92
CO2	3	3	3	2	3	2	X	X	2	3	X	3	2.00
CO3	3	2	3	2	3	2	X	X	1	2	X	2	1.67
CO4	3	2	3	2	3	2	X	X	1	X	X	2	1.50
CO5	3	2	3	2	3	2	X	X	X	X	X	2	1.42
CO6	3	2	3	2	2	3	X	X	2	2	1	1	1.75
Average	2.83	1.83	2.83	1.83	2.67	1.83	0.00	0.00	1.00	1.17	0.67	1.83	

FPGA based Instrumentation System Design

COURSE CODE: 18B1WEC733

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Digital Electronics, Basic

Electronics Course Objectives:

1. Learn and understand the FPGA design flow
2. Learn to implement basic arithmetic circuits and DSP algorithms in FPGA using IP cores.
3. Learn to determine circuit speed, to check timing violations and techniques to fix them.
4. Learn to apply the knowledge gained to break an algorithm into arithmetic functions and implement in FPGA with/without using IP cores.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Explain the concept and basic structures of Field Programmable Gate Array (FPGA), and techniques to implement programmable logic circuits using typical FPGA design flow	Familiarity
CO-2	Implementing basic arithmetic circuits and ASICs for simple DSP functions, such as filters using user defined or vendor provided IP cores	Assessment
CO-3	Determining circuit speed, checking timing violations and techniques to fix the timing violations.	Usage
CO-4	Design issues in cross clock domains communication in high-speed ASIC design	Assessment
CO-5	Break any given algorithm to sub-modules and implement the same on FPGA using HDLs and various IP cores	Usage

Course Contents:

Unit	Contents	Lectures required
1	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, FPGA-Based System Design Examples	6

2	Verilog HDL: 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, : FSM Types, Implementation in HDLs, a simple computer design, other Design examples and case studies	12
3	Digital System Design: Combinational and sequential circuits, Classification of sequential circuits, Registers. Design & analysis of synchronous and asynchronous sequential circuits: Counters.	6
4	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, Multi FPGA systems, multiple-clock domains, program and data memory, SRAM and DRAM., ROM, PAL, and PLA, Timing Constraints, using IP cores: instantiation and simulations	6
5	Instrumentation System: Basic concepts, Weighted Resistor D/A converter, A/D Converter, programmable ICs, digital potentiometers, various data communication and interfacing protocols (UART, SPI, I2C and others) and FPGA implementation case studies	12
Total lectures		42

Suggested Text Book(s):

1. Michael D. Ciletti: Advanced Digital Design with the Verilog HDL, 2nd Edition, Pearson, 2011.
2. Jean- Pierre Deschamps, Gustavo D. Sutter, Enique Cano: Guide to FPGA Implementation of Arithmetic Functions, Springer, 2012.

Suggested Reference Book(s):

1. Hamblen, J.O, Hall, T.S, and Furman, M.D., “Rapid Prototyping of Digital Systems, SOPC Edition." Springer, 2008.
2. Zainalabedin, Navabi, "Digital Design and Implementation with Field Programmable Devices", Springer, 2005.
3. 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, 2006.

Other useful resource(s):

1. FPGA manufacturer’s web resources:

   Altera Inc.: https://www.altera.com/products/general/fpga/stratix-fpgas/about/stx-asic-prototyping.html

   Xilinx: https://www.xilinx.com/applications/asic-prototyping.html

2. **Other Journal/research resources:**

   http://biomedical-engineering-online.biomedcentral.com/articles/10.1186/1475-925X-13-126

   http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.470.6049&rep=rep1&type=pdf

3. NPTEL Resources

   https://nptel.ac.in/courses/117108040/

   https://nptel.ac.in/courses/117106092/55

https://nptel.ac.in/syllabus/117108040/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (FPGA based Instrumentation System Design)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	2	3	1	2	2	x	1	3	3	1	2	1.67
CO-2	3	2	3	1	2	2	x	x	3	1	1	2	1.67
CO-3	3	3	3	2	3	2	x	x	3	2	1	2	2.00
CO-4	3	3	3	2	3	2	x	x	3	2	1	2	2.00
CO-5	3	3	3	3	3	2	x	x	3	2	1	2	2.08
Average	3	2.6	3	1.8	2.6	2	0	0	3	1.6	1	2	

Real Time Operating Systems

COURSE CODE: XXXXXXXX

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Prerequisites are basic knowledge of computer architecture and operating systems

Course Objectives:

1. Study of design of real time operating systems and their operations.
2. Design and analysis of real time system software.
3. Modeling and verification of real time systems
4. Use real time system programming languages and real time operating systems for real time applications.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Fundamental principles for programming of real time systems with time and resource limitations.	Familiarity
CO-2	Foundation for programming languages developed for real time programming.	Assessment
CO-3	How real time operating systems are designed and functions.	Assessment
CO-4	Study of application domains.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to UNIX/LINUX, Overview of Commands, File I/O,(open, create, close, lseek, read, write), Process Control (fork, vfork, exit, wait, waitpid, exec).	8
2	Brief History of OS, Defining RTOS, The Scheduler, Objects, Services, Characteristics of RTOS, Defining a Task, asks States and Scheduling, Task Operations, Structure, Synchronization, Communication and Concurrency. Defining Semaphores, Operations and Use, Defining Message Queue, States, Content, Storage, Operations and Use	8
3	Pipes, Event Registers, Signals, Other Building Blocks, Component Configuration, Basic I/O Concepts, I/O Subsystem	7
4	Exceptions, Interrupts, Applications, Processing of Exceptions and Spurious Interrupts, Real Time Clocks, Programmable Timers, Timer Interrupt Service Routines (ISR), Soft Timers, Operations.	7

5	RT Linux, Micro C/OS-II, Vx Works, Embedded Linux, and Tiny OS.	6
6	Fault – Tolerant Design: A Case Study, Case Study in Software Requirements Specification for Four way, Traffic Intersection Traffic Light Controller System.	6
Total lectures		42

Suggested Text Book(s):

1. Qing Li, "Real Time Concepts for Embedded Systems", 2011, Elsevier.

Suggested Reference Book(s):

1. Rajkamal, "Embedded Systems- Architecture, Programming, and Design", 2007, TMH.
2. W. Richard Stevens, Stephan A. Rago, "Advanced UNIX Programming", 2006, 2nd Edition, Pearson.
3. Dr. Craig Hollabaugh, "Embedded Linux: Hardware, Software and Interfacing", 2008, 1st Edition, Pearson.

Other useful resource(s):

Link to topics related to course:

1. https://nptel.ac.in/courses/106/105/106105172/
2. https://onlinecourses.nptel.ac.in/noc20_cs16/preview

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Real Time Operating Systems)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	3	3	2	1	1	1	2	2	2	2	1.91
CO-2	3	3	3	3	3	2	1	1	3	2	1	3	2.33
CO-3	2	3	2	2	2	2	2	2	2	2	1	2	2.00
CO-4	3	3	3	3	2	1	1	1	2	3	2	3	2.25
Average	2.50	2.75	2.75	2.75	2.25	1.50	1.25	1.25	2.25	2.25	1.50	2.50	

Digital CMOS ICs

COURSE CODE: _____-__

COURSE CREDITS: 3

CORE/ELECTIVE: PROFIENCY

: 3-4-0

Pre-requisite: VLSI Technology

(18B11EC612) Course Objectives:

1. To understand and learn to use CMOS in designing combinational circuits, sequential circuits, semiconductor memories including the design of arithmetic building blocks.
2. To learn various low power CMOS logic design techniques including the clock and IO circuits design issues.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To understand the MOS transistor as inverter, switch, its capacitance and CMOS logic gate design.	Familiarity
CO-2	To be able design and analyze combinational and sequential CMOS circuits and tradeoffs	Usage
CO-3	Able to design circuits using dynamic logic design technique	Usage, Assessment
CO-4	To understand and use the low power design techniques, methodologies and design practices to reduce the power dissipation of large scale CMOS digital ICs.	Assessment
CO-5	To understand the manufacturability and testability issues to be considered during the design phase of an IC	Familiarity

Course Contents:

Unit	Contents	Lectures required
1	Introduction to CMOS and its working as an inverter, review of delay time definitions, interconnect delay, switching power dissipation, sizing trends in CMOS inverter, delay constraints, MOSFETs, capacitances	5
2	Combinational logic circuits: Logic circuits with Pseudo-nMOS loads, CMOS Logic circuits, Complex logic circuits, CMOS Transmission Gates (Pass Gates)	5
3	Sequential Logic circuits: Behavior of bi-stable elements, SR Latch circuits, clocked latch and flip-flop circuits, clocked storage elements- timing parameters, CMOS D-latch and edge triggered Flip-Flop, Pulsed latch based clocked storage elements, Sense amplifier based Flip-Flops, Logic Embedding in clocked storage elements, Power consumption of clocking system and power saving methodologies.	11

4	Dynamic Logic circuits: Basic pass transistor circuits, voltage bootstrapping, synchronous dynamic circuit design techniques, Dynamic CMOS circuit design techniques, High performance Dynamic CMOS circuits	4
5	Dynamic Random access memory(DRAM), static random access memory (SRAM), Nonvolatile memory, Flash memory, Ferroelectric Random access memory (FRAM)	3
6	Low power CMOS Logic circuits: sources of power consumption, low power design through voltage scaling, estimation and optimization of switching activity, reduction of switched capacitance, adiabatic logic circuits	6
7	Design for manufacturability and testability: ESD protection, input circuits, output circuits and noise, On chip clock generation and distribution, latch-up and its prevention, process variations, design of experiments and performance modeling, parametric yield estimation, worst case analysis, performance variability minimization, fault types and models controllability and observability, adhoc testable design techniques, scan based techniques, built in self test (BIST), current monitoring tests	8
Total lectures		42

Suggested Text Book(s):

1. Sung-Mo Kang, Yusuf Leblebici, Chulwoo Kim: CMOS Digital Integrated Circuits Analysis and Design, fourth edition, Tata McGraw-Hill, 2016.
2. Thomas A. Demassa, Zack Ciccone: Digital Integrated Circuits, John Wiley & Sons (Asia) Pte., Ltd.
3. John P. Uyemura: Introduction to VLSI Circuits and Systems, John Wiley & Sons, Inc., 2002.

Suggested Reference Book(s):

1. Kaushik Roy, Sharat Prasad: Low power CMOS VLSI circuit Design, Wiley India, 2010.
2. Adel S. Sedra, Kenneth C. Smith: Microelectronics Circuits, 5th Ed., Oxford University, 2004.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/108106069/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Class performance, Tutorials & Assignments - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Digital CMOS ICs)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO1	3	3	2	3	2	2	2	1	1	1	2	3	2.08
CO2	3	3	3	2	2	2	2	1	1	2	1	3	2.08
CO3	3	3	3	3	3	2	1	1	1	1	1	2	2
CO4	3	3	3	3	3	3	1	1	1	1	1	2	2.08
CO5	3	2	2	2	3	2	1	1	1	1	1	2	1.75
CO6	3	3	3	3	3	3	3	1	1	1	1	3	2.33
Average	3.00	2.83	2.67	2.67	2.67	2.33	1.67	1	1	1.17	1.17	2.50	

CAD Algorithms for Synthesis of Digital Systems

COURSE CODE: XXXXXXX

COURSE CREDITS: 3

CORE/ELECTIVE: Elective

L-T-P: 3-0-0

Pre-requisite: Digital Electronics Course

Objectives:

1. To learn modern techniques and algorithms for synthesis and optimization of digital systems.
2. To provide the basic exposure of technology mapping.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Able to understand the design flow for the implementation of the of digital systems hardware design.	Familiarity
CO-2	Able to understand the concept of optimization in logic synthesis	Usage
CO-3	Able to understand the concept of optimization in Multi level logic synthesis and sequential logics.	Usage
CO-4	Able to understand the algorithm for Boolean decomposition	Usage
CO-5	Able to use the CAD tools for the synthesis of digital systems	Assessment

Course Contents:

S. No.	Contents	Contact Hours
1.	Introduction: Intro to VLSI CAD & Logic Synthesis, Graph Theory & Optimization problems, Boolean Algebra, Boolean Function Representation & Manipulation: BDDs, Satisfiability & Graph Covering	06
2	Exact & Heuristic Two-Level Logic Minimization: SOP & POS forms: Costs & Characteristics, Implicants, Cubes and Covers, Quine-McCluskey Method, Minimum Cover via Unate Covering, Branch-and-Bound Methods, Multi-Output Function Minimization, Unate Recursive Paradigm ,The ESPRESSO Minimizer	06
3	Multi-Level Logic Synthesis - Algebraic Techniques: Combinational Network Representation and Transformations , Factored Forms and Algebraic Techniques Alegbraic Division: Kernels and Co-Kernals, Heuristic Factoring Algorithms, The MIS MODEL	08
4	Boolean Decomposition: Functional Decomposition – Basics, Ashenhurst-Curtis Decomposition, BDS and Bi-Decomposition, Don’t Care Conditions & Their Computations, BDD-Based Boolean Decomposition 2, Decomposition for FPGAs • New Logic Synthesis approaches based on AND-Invert Graphs and Boolean Decomposition , The ABC Synthesis & Verification tool	08

5	Delay Optimization: Timing Analysis – Basics, False Path Analysis, Circuit Restructuring for Timing Optimization, Redundancy and Delay: KMS Algorithm Sequential Logic Optimization Finite State Machine Minimization, Two-Level Encoding: DIET & NOVA , Multi-Level Encoding: JEDI, Retiming of Sequential Circuits, Retiming, Resynthesis and Don't Cares Technology Mapping: Tree & DAG Covering, Standard Cell Mapping ,And-Invert Graphs ,Tech-mapping on FPGAs New Directions in Logic Synthesis : Limitations of Conventional Synthesis Tools, Multi-Valued Logic Synthesis, Reversible & quantum logic .	14
	Total	42

Suggested Text Book(s):

1. J. Bhasker, "Verilog VHDL synthesis: a practical primer", B S Publications, 1998.
2. Sait, S. M. and Youssef, Habib, VLSI Physical Design Automation – Theory and Practice, World Scientific, 2004.
3. Sherwani, N., Algorithms for VLSI Physicsl Design Automation, Springer. Third Ed. 2005.
4. Deba Prasad Das, VLSI design, Second Edition, Oxford Publishers, 2015
5. Micheli, Giovanni De. Synthesis and optimization of digital circuits. McGraw-Hill Higher Education, 1994.

Suggested Reference Book(s):

1. S. Ramachandran, "Digital VLSI systems design", Springer, 2007.
2. R.H. Katz, "Contemporary logic design", Addison-Wesley Pub. Co., 1993.
3. M.J.S. Smith, "Application-specific integrated circuits", Addison-Wesley Pub. Co., 1997.
4. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing", Kluwer Academic Publishers, 2000.
5. D.D. Gajski, N.D. Dutt, A.C. Wu and A.Y. Yin, "High-level synthesis: introduction to chip and system design", Kluwer Academic Publishers, 1992.
6. Andrew B. Kahng, J. Lienig I. L. Markov,J. Hu, VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer, 2011.

Other useful resource(s):

1. http://www.facweb.iitkgp.ac.in/~isg/CAD/SLIDES/01-intro.pdf
2. http://jjackson.eng.ua.edu/courses/ece380/lectures/LECT06.pdf
3. https://canvas.instructure.com/courses/1066166/modules
4. http://www.cs.columbia.edu/~cs6861/handouts/syllabus.pdf
5. https://my.ece.utah.edu/~kalla/ECE5740/syllabus.pdf
6. http://unina.stidue.net/Architettura%20dei%20Sistemi%20di%20Elaborazione/Materiale/G.%20De%20Micheli%20%20Synthesis%20And%20Optimization%20Of%20Digital%20Circuits%20%28Text%20Recognized%20Using%20OCR%29%20%5Bv.%201.03%2020-4-2005%5D.pdf

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (CAD Algorithms for Synthesis of Digital Systems)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	2	2	3	3	3	3	3	3	3	2.8
CO-2	3	3	3	3	3	3	3	3	3	3	2	2	2.8
CO-3	3	3	3	3	2	2	2	3	2	3	3	2	2.6
CO-4	3	2	3	3	3	3	2	2	3	2	3	3	2.7
CO-5	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	3	2.8	3	2.8	2.6	2.8	2.6	2.8	2.8	2.8	2.8	2.6	

Communication Engineering

COURSE CODE: 18B1WEC532

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Signals & Systems, Basic Course in Probability. Course Objectives:

1. To understand the use of communication in the field of satellites and the concept of spread spectrum.
2. To make the students familiar with the implications of laws of information theory and coding with reference to the application in communication engineering.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Students will be familiar with the various fields/trends of communications like Satellite communication, Information theory and coding, and spread spectrum technique related to radio and telecommunication.	Familiarity
CO-2	To analyze the error performance of digital modulation systems in the presence of noise.	Assessment
CO-3	Design link power budget for satellite communication.	Assessment
CO-4	Design the channel based on given constraint using information theory.	Assessment
CO-5	Apply various codes like linear block codes, convolution codes etc. for channel performance analysis.	Usage
CO-6	Analyze the performance of spread spectrum systems in jamming environment.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Baseband Transmission and Pass band Digital Modulation: Matched Filter, Inter Symbol Interference, Eye Pattern, Overview of ASK, FSK, PSK, and QAM, Basics of MSK, Signal Constellations, Probability of error analysis of modulation schemes.	6
2	Communication Link Analysis: The Channel, Error-Performance Degradation, Sources of Signal Loss and Noise, Received Signal Power and Noise Power, Link Budget Analysis, Noise Figure, Noise Temperature, System temperature, Sample Link Analysis.	9

3	Fundamental Limits in Information Theory: Uncertainty, Information, Entropy, Source-Coding Theorem, Data Compaction, Discrete Memoryless Channels, Mutual Information, Channel Capacity, Channel-Coding Theorem.	9
4	Error-Control Coding: Introduction, Linear Block Codes, Syndrome, Syndrome Decoding, Cyclic Codes, Generator Polynomial, Parity-Check Polynomial, Convolution Codes, Code tree, Trellis Diagram, Maximum Likelihood Decoding of Convolution Codes, Viterbi Algorithm.	10
5	Spread-Spectrum Modulation: Introduction, Pseudo-Noise Sequences, Direct Sequence Spread Spectrum with coherent BPSK, Signal-Space Dimensionality and Processing Gain, Frequency Hopping Spread Spectrum.	8
Total lectures		42

Suggested Text Book(s):

1. Simon Haykin, "Communication Systems", 4th Ed., John Wiley & Sons, 2004.
2. Bernard Sklar and P. K. Ray, "Digital Communications: Fundamentals and Applications", 2nd Ed., Pearson Education, 2012.

Suggested Reference Book(s):

1. B. P. Lathi and Zhi Ding, "Modern Digital and Analog Communication Systems", 4th Ed., Oxford, 2010.

Other useful resource(s):

Link to NPTEL course contents: https://nptel.ac.in/courses/117105131/16

Link to NPTEL course contents: https://nptel.ac.in/courses/117101053/1

Link to NPTEL course contents: https://nptel.ac.in/courses/117105136/1

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (2) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course Outcomes (Communication Engineering)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	1	2	1	2	1	2	2	3	2.17
CO-2	3	3	3	3	3	2	2	2	1	1	1	3	2.25
CO-3	3	3	3	3	2	3	3	2	1	2	3	3	2.58
CO-4	3	3	3	2	2	1	1	1	1	2	3	3	2.08
CO-5	3	3	3	2	3	2	1	2	1	2	3	3	2.33
CO-6	3	3	2	2	2	3	3	2	2	3	3	3	2.58
Average	3.00	3.00	2.83	2.50	2.17	2.17	1.83	1.83	1.17	2.00	2.50	3.00	

Optical Communication Systems

COURSE CODE: 18B1WEC633

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Communication Systems

Course Objectives:

1. To understand the constituents of the fiber optics communication system and optoelectronics.
2. To have an in depth knowledge of practically used optical communication systems

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand basics of optical communication systems.	Familiarity
CO-2	The principles that govern optical communication systems.	Familiarity
CO-3	Behavior of light as electromagnetic waves in different types of fibers.	Assessment
CO-4	The hardware components required to implement optical communication systems.	Assessment
CO-5	To efficiently design an optical communication system for practical purpose.	Usage
CO-6	The practical techniques involved in optical communication systems.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Fiber optics and Optoelectronics, Historical developments, Fiber optic communication system, Advantages, Emergence as a key technology, Role of Fiber optics technology.	5
2	Ray Propagation in Optical Fibers: Review of fundamental laws of optics, Ray propagation in Step-index and Graded-index Fibers, Effect of material dispersion, The combined effect of multipath and material dispersion, Calculation of rms pulse width.	8
3	Wave propagation in Waveguides: Maxwell's equations, Solution in a inhomogeneous medium, Planar optical waveguide, TE modes of a symmetric step-index planar waveguide, Power distribution and confinement factor, Modal analysis of an ideal SI optical fiber.	8
4	Single-mode Fibers and Multimode Fibers: Single-mode fibers, Characteristics parameters of SMFs, Dispersion in SMFs, Attenuation in SMFs, Graded-index fibers, Limitations of multimode fibers.	7

5	Optoelectronic Sources and Detectors: Fundamental aspects of semiconductor physics, the p-n junction, Current densities and injection efficiency, The basic principle of optoelectronic detection. Types of photodiodes, Photoconducting detectors, Noise considerations.	8
6	Optoelectronic Modulators and Amplifiers: Review of basic principles, Electro-optic modulators, Semiconductor optical amplifiers.	6
Total lectures		42

Suggested Text Book(s):

1. Optical Fiber Communications, John M Senior, 3rd Edition, PHI, 2009.
2. Fiber Optic Communication Systems, Govind P. Agarwal, 4th Edition, Wiley, 2010.
3. Fiber Optics and Optoelectronics, R.P. Khare Oxford University Press, 2015

Suggested Reference Book(s):

1. Fiber Optic Communications, S. Kumar and M. J. Deen, Wiley, 2014.
2. Optical Fiber Communications, G. Keiser, 5th Edition, Tata McGraw Hill, 2009.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/117101002/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Optical Communication Systems)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	2	2	2	2	1.75
CO-2	2	3	3	3	3	1	1	1	2	2	1	2	2
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	1.75
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	2.08
CO-5	2	3	3	3	2	1	1	1	2	3	2	2	2.08
CO-6	2	3	3	3	2	1	1	1	2	3	2	2	2.08
Average	2	2.66	2.66	2.66	2.66	1	1	1	2	2.5	1.66	2	

Next Generation Communication Systems

COURSE CODE: 18B1WEC732

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic knowledge of wireless communication and probability theory

Course Objectives:

1. To analyze the channel parameters effects on communication system.
2. Understanding of advanced techniques employed for improvement of communication system.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the basics of communication system and various standards used in different generation.	Familiarity
CO-2	Understand the modeling of channel used in communication.	Familiarity
CO-3	Analyze the effect of various parameters on the performance of communication system.	Assessment
CO-4	Demonstrate the various techniques for performance improvement of communication system	Assessment
CO-5	Apply advanced techniques to next generation communication system	Usage

Course Contents:

Unit	Contents	Lectures required
1	CDMA: Introduction to various generation of cellular communication systems and standards, Introduction to CDMA and Spread Spectrum, Generation and Properties of PN Sequences, correlation between PN Sequences, Walsh Code, Variable tree OVSF, LFSR, Rake Receiver, Near-Far effect, Multi user CDMA uplink and downlink.	9
2	Channel Characterization of Next generation communication system: BER and SNR analysis of wired and wireless channels, Effect of various channel parameters on performance of wireless communication system, Doppler shift.	6
3	Diversity & Equalization: Diversity System Model, Receiver Diversity: selection diversity, feedback diversity, maximal ratio combining, equal gain combining, Equalizers, Types of Equalizers: linear equalizers, non-linear equalizers.	9
4	Principles of OFDM and MIMO wireless communication: Introduction to OFDM, OFDM Block Diagram, MIMO Wireless Communication, Benefits of MIMO Technology, MIMO OFDM Building Block, Capacity Comparisons of SISO, SIMO, MISO, and MIMO.	9

5	Singular Value Decomposition, Software Defined Radio , Cognitive Radio	9
Total lectures		42

Suggested Text Book(s):

1. T.S. Rappaport, "Wireless Communication", 2nd Edition, Prentice Hall., 2002.
2. A.Goldsmith, " Wireless communication" 1st Edition , Cambridge University Press,2005.
3. Ye Li and Gordon L. Stuber, "Orthogonal Frequency Division Multiplexing for Wireless Communications" 1st Edition, Springer, 2006.

Suggested Reference Book(s):

1. Huseyin Arslan: Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems, 1st Edition, Springer, 2007.
2. Hui Liu, "OFDM based broadband wireless networks: design and optimization" , 1st Edition, John Wiley & Sons, 2006.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/117104099/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programmed Outcomes (POs)

Course outcomes (Next Generation Communication Systems)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	2	2	1	2	2	2	1	2	2	2	1.92
CO-2	3	3	3	3	2	2	1	1	1	2	2	2	2.08
CO-3	3	3	3	3	2	1	1	1	1	2	1	1	1.83
CO-4	2	3	3	2	2	1	1	1	1	2	1	3	1.83
CO-5	3	2	2	2	3	2	2	1	1	2	2	2	2.00
Average	2.6	2.8	2.6	2.4	2	1.6	1.4	1.2	1	2	1.6	2	

OFDM and Applications

COURSE CODE: 18B1WEC736

COURSE CREDITS: 3

CORE/ELECTIVE: Elective

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. Learn the fundamental concepts of high rate OFDM communication system focusing on the physical layer.
2. Analyze the design requirements of various OFDM standards.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Learn the fundamentals of OFDM communication system.	Familiarity
CO-2	Performance analysis of OFDM signals over AWGN and wideband channels.	Assessment
CO-3	Demonstrate the challenging issues in OFDM system.	Assessment
CO-4	Apply OFDM to the practical communication systems.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction and Basics of OFDM: High rate wireless applications; Wireless channel; Interference and noise; OFDM concept and system model- block diagram, design of the OFDM signal, OFDM system model, FFT implementation, cyclic extension, power spectrum and spectrum efficiency, synchronization errors; Channel capacity and OFDM; Comparison with single-carrier; Design example; Performance of an uncoded OFDM system.	10
2	Impairments of Wireless Channels to OFDM Signals: Time varying impairments; Effect of sampling clock offset; Effect of timing offset; Effect of delay spread; System Non Linearity. Other Multicarrier Modulation; Mathematical modeling and analytical evaluation of the BER of OFDM System.	8
3	OFDM Transmission over Gaussian channels and wideband channels. Synchronization: Overview of synchronization schemes- timing offset estimation, frequency offset estimation, acquisition versus tracking; Timing offset estimation- pilot based methods, non-pilot based methods; Frequency offset estimation- pilot based methods, non-pilot based methods; Joint time and frequency offset estimation and correction.	8

4	OFDM versus-MC-CDMA: Peak Power Ratio: The peak power problem; Distribution of PAP ratio; Maximum PAPR of an N subcarrier OFDM signal; PAPR reduction with signal distortion; Limits for distortion-less PAPR-reduction; Techniques for distortion-less PAPR reduction-selective mapping, optimization techniques, modified signal constellation; PAPR reduction effect on the system performance; PAPR reduction for multicarrier CDMA.	8
5	OFDM applications: MIMO OFDM- synchronization for MIMO OFDM, A practical OFDM system: Fixed broadband wireless access, system requirements, parameter selection, communication protocol, frame structure, MAC consideration and conformance.	8
Total lectures		42

Suggested Text Book(s):

1. Ye Li and Gordon L. Stuber: Orthogonal Frequency Division Multiplexing for Wireless Communications, 1st Edition, Springer, 2006.
2. Ramjee Prasad: OFDM for Wireless Communications Systems, 1st Edition, Artech House Publishers, 2004.
3. Lazos Hanzo: OFDM and MC-CDMA: A primer, 1st Edition, Wiley-IEEE Press, 2006

Suggested Reference Book(s):

1. Richard Van Nee: OFDM for Wireless Multi-Media Communication, 1st Edition, Artech, House Publishers, 2000.
2. Hui Liu: OFDM based Broadband Wireless Networks: Design and Optimization, 1st Edition, John Wiley & Sons, 2006.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/117104099/
2. Link to topics related to course:
   https://nptel.ac.in/courses/117104099 /27
   https://nptel.ac.in/courses/117104099 /28
   https://nptel.ac.in/courses/117104099 /29
   https://nptel.ac.in/courses/117104099 /30
   https://nptel.ac.in/courses/117104099 /31
   https://nptel.ac.in/courses/117104099 /34

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (OFDM and its Applications)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	2	3	1	3	1	1	1	2	2	1	3	1.92
CO-2	3	3	3	3	3	2	1	1	2	2	1	3	2.25
CO-3	2	2	3	3	2	1	1	1	2	1	1	3	1.83
CO-4	2	1	3	3	3	2	1	1	1	1	1	2	1.75
Average	2.5	2	3	2.5	2.75	1.5	1	1	1.75	1.5	1	2.75	

Cognitive Radio Networks

COURSE CODE: 18B1WEC834

COURSE CREDITS: 3

CORE/ELECTIVE: Elective

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To understand the principles, applications and challenges of cognitive radio technology.
2. Analyze the design of wireless networks based on cognitive radio technology.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the fundamental issues regarding dynamic spectrum access and radio-resource management.	Familiarity
CO-2	Analyze the emerging issues in cognitive radio network.	Assessment
CO-3	Apply different spectrum sharing models in the Cognitive Radio Network.	Assessment
CO-4	Apply efficient sharing of the unutilized spectrum among cognitive and licensed users while avoiding interference to the licensed user due to cognitive user's transmission	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Cognitive Radio: Spectrum scarcity, Spectrum white space, Fixed spectrum allocation, Software defined radio (SDR), Limitations of SDR, Evolution of cognitive radio, Dynamic spectrum access, Introduction to cognitive radio concept, Cognitive cycle, Functions of cognitive radio; spectrum sensing, spectrum management, spectrum mobility, Cognitive radio architecture, Interference temperature and its models.	8
2	Spectrum Sensing and Challenges in Cognitive Radio Network: Hypothesis model for spectrum sensing, Types of spectrum sensing; Non-cooperative sensing, Cooperative sensing, Interference-based sensing, Matched filter detection, Energy detection, Cyclostationary feature detection, advantages and disadvantages of various spectrum sensing techniques, False alarm, Miss detection, Optimal sensing framework for infrastructure based cognitive radio network. Research challenges in spectrum sensing, spectrum management and spectrum mobility, potential applications of cognitive radio, IEEE 802.22 for WRANs	8

3	Spectrum Sharing and Management: Dynamic spectrum Access (DSA): models and architectures, Opportunistic spectrum access (OSA), Antenna Systems, MIMO systems, Smart antenna and beamforming. SDR architecture, Software tunable analog radio components, Reconfigurable digital radio technologies.	8
4	Cross Layer Adaptation and Security in Cognitive Radio: Why we need cross-layer design, adaptation and optimization, Cognitive radio cross layer design, security challenges in cognitive radio. OFDM for Cognitive Radio: OFDM based cognitive radio, Why OFDM is a good fit for Cognitive radio, Challenges to cognitive OFDM systems, Multiband OFDM, A step toward cognitive-OFDM: standards and technologies.	9
5	Cognitive Radio Regulation and Standardization: regulatory issues and new spectrum management regimes, spectrum planning, Spectrum authorization, Standards and international activities. UWB Cognitive Radio: Introduction, Fundamentals of impulse radio Ultra Wideband, Cognitive radio requirements versus IR-UWB, Merging impulse radio with cognitive radio.	9
Total lectures		42

Suggested Text Book(s):

1. Ekram Hossain, Dusit Niyato and Zhu Han: Dynamic Spectrum Access and Spectrum Management in Cognitive Radio Networks, 1st Edition, Cambridge University Press, 2009.
2. Huseyin Arslan: Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems, 1st Edition, Springer, 2007.
3. Bruce A. Fette: Cognitive Radio Technology, 2nd Edition, Academic Press, April 6, 2009.

Suggested Reference Book(s):

1. Yang Xiao and Fei Hu: Cognitive Radio Networks, 1st Edition, CRC Press, 2008.
2. Linda E. Doyle: Essentials of Cognitive Radio, 1st Edition, Cambridge University Press, 2009.

Other useful resource(s):

Link to GIAN IIT Kanpur course contents (10 lecture series):
https://www.youtube.com/watch?v=SljXFf0vgvw&list=PL48UwQJyfW3SmrjLgl5LrVciqfWz9XazY

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Cognitive Radio Networks)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	2	2	2	1	2	1	2	2	3	2.08
CO-2	3	3	3	3	2	1	1	1	2	2	1	2	2
CO-3	3	3	3	2	2	2	1	2	2	2	1	3	2.17
CO-4	3	3	3	3	2	1	1	1	2	3	2	3	2.25
Average	3	3	2.75	2.5	2	1.5	1	1.5	1.75	2.25	1.5	2.75	

Wireless Communication and Mobile Networks

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite:

None

Course Objectives:

1. To introduce students to the basic concepts and techniques of wireless communication.
2. To become familiar with technology employed in next generation of mobile communication.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understanding of evaluation of wireless system	Familiarity
CO-2	Acquire knowledge of cellular systems	Familiarity
CO-3	Modelling and analysis of fading channels in wireless system	Usage
CO-4	In depth knowledge of various techniques used in wireless mobile system.	Assessment
CO-5	Understanding of GSM, 4G and 5 G network	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	Introduction to wireless and mobile communication: Evolution of mobile radio communication fundamentals. General model of wireless communication link, Types of Signals, Cellular Infrastructure, Cellular System Components, Antennas for Cellular Systems, Operation of Cellular Systems,	5
2.	Channel Assignment, Frequency reuse, Channel Assignment strategies, Handoff Strategies Cellular Interferences, Sectorization; Wireless Channel and Radio Communication, Free Space Propagation Model, Channel Noise and Losses, Fading in Land Mobile Systems, Multipath Fading, Fading Effects on Signal and Frequency, Shadowing.	5
3.	Wireless Channel Modeling: AWGN Channel, Rayleigh Channel, Rician Fading Channel, Nakagami Fading Channel, Ocumura and Hata Path Loss Model; Channel Modelling: Stochastic, Flat Fading, Wideband Time Dispersive Channel Modelling	8

4.	Theory of Vocoders, Types of Vocoders; Spread Spectrum Modulation, Pseudo-Noise Codes with Properties and Code Generation Mechanisms, DSSS and FHSS Systems, Time Hopping and Hybrid Spread Systems; Multicarrier Modulation Techniques. Zero Inter Symbol Interference Communication Techniques, Detection Strategies, Diversity Combining Techniques: Selection Combining, Threshold Combining, Equal Gain Combining, Maximum Ratio Combining; Spatial Diversity and Multiplexing in MIMO Systems, Channel Estimation.	9
5.	Equalization Techniques: Adaptive Equalizers, Zero Forcing Equalizers, Decision Feedback Equalizers, GSM system for mobile Telecommunication: GSM Architecture, Fundamentals of GSM Network, GSM Channels, Waveform Coding and Call Flow in GSM, Waveform Coding, GSM Vocoders, Call flow in GSM.	9
6.	Introduction to 4G, 5G and concept of NGN	6
Total lectures		42

Suggested Text Book(s):

1. T.S. Rappaport, "Wireless Communication", 2nd Edition, Prentice Hall., 2010.
2. A.Goldsmith, " Wireless communication" 1st Edition , Cambridge University Press, 2005.

Suggested Reference Book(s):

1. G. S. Rao, " Mobile Cellular Communication", Pearson Education, 2012.
2. K. Feher, "Wireless Digital Communications", PHI,1999.

Other useful resource(s):

1. Link to NPTEL course contents: Advanced 3G and 4G Wireless Mobile Communications https://www.youtube.com/watch?v=-ymnQ5rpcYA&list=PLbMVogVj5nJSi8FUsvglRxLtN1TN9y4nx

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs):

CO/PO (Wireless Communication and Mobile Networks)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO1	2	3	2	2	2	2	2	1	1	2	3	3	2.08
CO2	2	3	3	2	3	2	2	1	1	2	2	3	2.16
CO3	3	2	3	3	3	3	1	2	3	3	3	3	2.66
CO4	3	3	3	3	3	3	3	1	3	3	3	2	2.75
CO5	3	3	2	3	3	3	3	1	3	3	3	3	2.75
Average	2.6	2.8	2.6	2.6	2.8	2.6	2.2	1.2	2.2	2.6	2.8	2.8	

Introduction to Machine Learning

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite:

None

Course Objectives:

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To become familiar with regression methods, and classification methods.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Gain knowledge about basic concepts of Machine Learning	Familiarity
CO-2	Understand complexity of Machine Learning algorithms and their limitations	Familiarity
CO-3	Solve the problems using various machine learning techniques	Usage
CO-4	Design application using machine learning techniques	Assessment
CO-5	Capable of performing experiments in Machine Learning using real-world data.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Overview of intelligent systems and machine learning, Supervised learning, Unsupervised learning, Reinforcement learning, Bias-variance trade-off, Overfitting, Underfitting, Goals and applications of machine learning	5
2	Linear Regression with One Variable: Model representation, Cost function, Gradient descent, Gradient descent for linear regression	4
3	Linear Algebra: Matrices and vectors, Addition and scalar multiplication, Matrix vector multiplication, Matrix multiplication, Matrix multiplication properties, Inverse and transpose, Multivariable calculus, and Modern applications	3

4	Linear Regression with Multiple Variables: Multiple features, Gradient descent for multiple variables, Feature scaling, Learning rate, Features and polynomial Regression, Normal equation, Noninvertibility	6

5	Logistic Regression: Classification, Hypothesis representation, Decision boundary, Cost function, Simplified cost function and Gradient descent, Advanced optimization, Multiclass classification: One-vs-all	6
6	Bayesian Learning: Probability theory and Bayes rule, Naive Bayes learning algorithm, Parameter smoothing, Generative vs. discriminative training, Bayes nets and Markov nets for representing dependencies.	6
7	Regularization: The Problem of overfitting, Cost function, Regularized linear regression, Regularized logistic regression	4
8	K-Nearest Neighbours: Introduction, KNN algorithm, Parameter selection , KNN as Classifier, KNN as Regressor, Applications	4
9	Machine Learning System Design: Error analysis, Error metrics for skewed classes, Trading off precision and recall, Data for Machine Learning	4
Total lectures		42

Suggested Text Book(s):

1. C. Bishop: Pattern Recognition and Machine learning, Springer, 2006.
2. H. Daume: A course in Machine leaning, 2015.
3. Ethem Alpaydin, “Introduction to Machine Learning”, Second Edition, The MIT Press, Cambridge, 2010.

uggested Reference Book(s):

1 T. Hastie, R. Tibshirani, J. Friedman: The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2013.

2. Stephen Marsland, “Machine Learning: An Algorithmic Perspective”, Second Edition, Chapman and Hall/CRC, 2014.

Other useful resource(s):

1. Link to NPTEL course contents: Introduction to Machine Learning https://onlinecourses.nptel.ac.in/noc17_cs26/preview
2. Link to MITOPENCOURESEWARE: Machine Learning https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867-machine-learning-fall-2006/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO (Introduction to Machine Learning)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO1	3	3	2	2	2	2	2	1	1	2	3	3	2.17
CO2	3	3	3	2	3	2	2	1	1	2	3	3	2.33
CO3	3	3	3	3	3	3	3	1	3	3	3	3	2.83
CO4	3	3	3	3	3	3	3	1	3	3	3	3	2.83
CO5	3	3	3	3	3	3	3	1	3	3	3	3	2.83
Average	3.00	3.00	2.80	2.60	2.80	2.60	2.60	1.00	2.20	2.60	3.00	3.00	

Machine Learning for Data Analysis

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Introduction to Machine Learning

(20B1WEC531) Course Objectives:

1. To provide a broad survey of approaches and techniques in machine learning;
2. To develop the design and programming skills that will help you to build intelligent, adaptive artifacts.
3. To develop the basic skills necessary to pursue research in machine learning.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the basic theory underlying machine learning.	Familiarity
CO-2	Understand a range of machine learning algorithms along with their strengths and weaknesses.	Usage
CO-3	Apply machine learning algorithms to solve problems of moderate complexity.	Assessment
CO-4	Formulate machine learning problems corresponding to different applications.	Assessment
CO-5	Read current research papers and understand the issues raised by current research.	Usage

Unit	Contents	Lectures required
1	Introduction: Definition of learning systems, Goals and applications of machine learning, Aspects of developing a learning system: training data, concept representation, function approximation.	3
2	Data Exploration and Pre-processing: Data objects and attributes; Statistical measures, Visualization, Data cleaning and integration	4
3	Decision Tree based Learning: Decision tree induction, Attribute selection and tree pruning.	5
4	Support Vector Machines: Maximum margin linear separators, Quadractic programming solution to finding maximum margin separators, Kernels for learning non-linear functions.	5
5	Dimensionality Reduction: Discriminant analysis; Principal component analysis, Independent component analysis; Transform Domain and statistical feature extraction and reduction.	7
6	Clustering and Unsupervised Learning: Learning from unclassified data,	8

	Clustering, Hierarchical Aglomerative Clustering, k-means clustering, Density based clustering.	
7	Artificial Neural Networks: Single layer neural network, Multilayer Perceptron, Back Propagation learning, Functional link artificial neural network, Radial basis function network, Recurrent neural networks, Convolution neural network.	10
Total lectures		42

Suggested Text Book(s):

1. J. Watt, R. Borhani and A. K. Katsaggelos: Machine Learning Refined: Foundations, Algorithms and Applications, Cambridge University Press, 1st ed., 2016.
2. C. Bishop: Pattern Recognition and Machine Learning, Springer, 1st ed., 2006.
3. J. Han, M. Kamber, J. Pei: Data Mining: Concepts and Techniques, Elsevier Amsterdam, 3rd ed., 2011

Suggested Reference Book(s):

1. T. Hastie, R. Tibshirani, J. Friedman: The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2013.
2. H. Simon: Neural Networks and Learning Machines, Prentice Hall, 3rd ed., 2009.

Other useful resource(s):

1. H. Daume: A course in Machine Leaning, 2015. http://ciml.info/
2. Link to NPTEL course contents: Introduction to Machine Learning https://onlinecourses.nptel.ac.in/noc17_cs26/preview
3. Link to MITOPENCOURESEWARE: Machine Learning

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867-machine-learning-fall-2006/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (3) - 10 Quizzes (3) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Machine Learning and Data Analytics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	2	2	2	2	1	1	2	3	3	2.17
CO-2	3	3	3	2	3	2	2	1	1	2	3	3	2.33
CO-3	3	3	3	3	3	3	3	1	3	3	3	3	2.83
CO-4	3	3	3	3	3	3	3	1	3	3	3	3	2.83
CO-5	3	3	3	3	3	3	3	1	3	3	3	3	2.83
Average	3.00	3.00	2.80	2.60	2.80	2.60	2.60	1.00	2.20	2.60	3.00	3.00	

Pattern Analysis in Machine Intelligence

COURSE CODE: XXXXXXXX

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite:

None

Course Objectives:

1. To introduce the concept of patterns for data analysis.
2. To analyze patterns to make machine take some decision.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the concept and representation of patterns in different data.	Familiarity
CO-2	Understand and able to visualize the concept and methodology of different feature extraction and feature selection methods.	Usage
CO-3	Able to understand the methodology of different classifiers.	Assessment
CO-4	Understand the concept of unsupervised learning for pattern recognition.	Assessment
CO-5	Able to implement different classifiers and their combinations for different applications.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Definitions, data sets and Different Paradigms of Pattern Recognition, Representations of Patterns and Classes.	6
2	Feature Extraction and Selection: Metric and non-metric proximity measures, Feature extraction and different approaches to Feature Selection.	12
3	Introduction to Supervised learning: Bayes Classifier, Decision Trees, Linear Discriminant Function and Support Vector Machines.	12
4	Introduction to Unsupervised learning: Clustering Methods	6
5	Combination of Classifiers for different applications.	6
Total lectures		42

Suggested Text Book(s):

1. R. O. Duda, P.E. Hart and D. G.Stork,,"Pattern Classification", 2nd Ed., Wiley, 2000.
2. H. Simon, "Neural Networks and Learning Machines",3rd ed., Prentice Hall, 2009.

Suggested Reference Book(s):

1. Jiawei Han, Jian Pei, Micheline Kamber, "Data Mining: Concepts and Techniques", 3rd ed., Elsevier Amsterdam, 2011.
2. C. Bishop, "Pattern Recognition and Machine learning", 1st ed., Springer, 2006.

Other useful resource(s):

1. https://nptel.ac.in/courses/117105101/ (Prof P.K. Biswas, IIT Kharagpur)
2. http://www.cs.ucsb.edu/~yfwang/courses/cs290i_prann/index.html (Prof. Yuan-Fang Wang)

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Pattern Recognition in Machine Intelligence)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	3	3	1	1	1	1	3	1	3	2.2
CO-2	3	3	3	3	3	1	1	1	2	3	1	3	2.2
CO-3	3	3	3	3	3	2	2	2	2	3	1	3	2.5
CO-4	3	3	3	3	3	2	2	2	2	3	1	3	2.5
CO-5	3	3	3	3	3	2	2	2	2	3	2	3	2.6
Average	3	3	2.8	3	3	1.6	1.6	1.6	1.8	3	1.2	3	

Optimization Techniques

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: Elective

L-T-P: 3-0-0

Pre-requisite: Basics of engineering mathematics Course Objectives:

1. To lay strong foundations in understanding the importance of optimization techniques.
2. To apply the theoretical knowledge acquired to various applications.
3. To analyze and appreciate variety of performance measures for various optimization problems.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To formulate and solve linear programming problems.	Familiarity
CO-2	To solve the problems on networks models such as Transportation, Assignment, Shortest path, minimal spanning tree, and Maximal flow.	Usage
CO-3	To solve the problems of Project Management using CPM and PERT	Usage
CO-4	Solve Non-linear Programming problems of some kinds.	Familiarity and Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Operation Research: Operation Research approach, scientific methods, introduction to models and modeling techniques, general methods for Operation Research models, methodology and advantages of Operation Research, history of Operation Research.	8
2	Linear Programming (LP): Introduction to LP and formulation of Linear Programming problems, Graphical solution method, alternative or multiple optimal solutions, Unbounded solutions, Infeasible solutions, Maximization – Simplex Algorithm, Minimization – Simplex Algorithm using Big-M method, Two phase method, Duality in linear programming, Integer linear programming.	8
3	Transportation & Assignment Problems: Introduction to Transportation problems, various methods of Transportation problem, Variations in Transportation problem, introduction to Assignment problems, variations in Assignment problems.	6

4	Network Analysis: Network definition and Network diagram, probability in PERT analysis, project time cost trade off, introduction to resource smoothing and allocation.Sequencing: Introduction, processing N jobs through two machines, processing N jobs through three machines, processing N jobs through m machines.	8
5	Inventory Model: Introduction to inventory control, deterministic inventory model, EOQ model with quantity discount.	6
6	Non-Linear Programming: Characteristics, Concepts of convexity, maxima and minima of functions of n-variables using Lagrange multipliers and Kuhn-Tuker conditions, One dimensional search methods, Fibonacci, golden section method and gradient methods for unconstrained problems.	6
Total lectures		42

Suggested Text Book(s):

1. J K Sharma, Operations Research Theory and Applications, MacMillan India Ltd.
2. N D Vohra, Quantitative Techniques in management, Tata McGraw Hill.
3. Handy A Taha, Operations Research – An Introduction, Prentice Hall of India, New Delhi.

Suggested Reference Book(s):

1. Wagner H M, Principles of Operations Research: With Applications to Management Decisions, Prentice-Hall of India, New Delhi.
2. Hillier F S and Lieberman G J, Operations Research, Holden Day Inc., San Francisco.
3. Payne T A, Quantitative Techniques for Management: A Practical Approach, Reston Publishing Co. Inc., Virginia.
4. Wilkes F M, Baum P and Smith G D, Management Science: An introduction, John Wiley and Sons, Santa Barbara.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/111/105/111105039/ https://nptel.ac.in/courses/105/108/105108127/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Optimization Techniques)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	1	1	1	2	1	2	1.7
CO-2	2	3	2	3	2	2	1	1	1	2	1	2	1.8
CO-3	3	3	3	3	3	2	1	1	1	2	1	2	2.1
CO-4	2	2	2	2	2	2	1	1	1	3	1	2	1.8
Average	2.25	2.5	2.25	2.5	2.25	2.0	1.0	1.0	1.0	2.25	1.0	2.0	

Artificial Intelligence Techniques

COURSE CODE: 18B1WEC838

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Prerequisites are good programming skills, basic data structures and algorithms, and some university level mathematics.

Course Objectives:

1. Learn to create expert systems which exhibit intelligent behavior.
2. Learn to create expert systems which exhibit the capability to learn, demonstrate, explain and advice its users.
3. Learn to help machines finding solutions to the complex problems.
4. Learn to design human like machines in a computer friendly manner.
5. To study State of the Art algorithms with engineering applications.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Analyze the need and foundation of Artificial Intelligence	Familiarity
CO-2	Study the Intelligent agents that receive percepts from the environment and perform actions	Assessment
CO-3	Analysis of problem solving, knowledge and reasoning	Assessment
CO-4	Study of application domains.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Artificial Intelligence (AI): The History and foundations of AI, Philosophy of AI, Intelligent Agents and Knowledge based Systems, AI Problem Solving, AI Learning and AI Perception, Real World AI.	8
2	Intelligent Agents: Agents and Environments, The concept of Rationality, Performance Measures, The structure of Agents, Agent Programs, Simple reflex Agents, Model based reflex Agents, Goal based Agents, Utility based Agents, Learning Agents.	8
3	Problem Solving: Problem solving Agents, Formulating Problems, Searching for Solutions, Uninformed Search Strategies, Breadth first search, Depth first search, Depth limited Search, Bidirectional search, Informed Search Exploration, Constraint Satisfaction Problems.	7

4	Knowledge and Reasoning: Knowledge based agents, Reasoning Patterns in Propositional Logic, Forward and Backward Chaining, Back tracking Algorithm, First Order Logic, Knowledge Representation, Uncertain Knowledge and Reasoning	7
5	Learning, Perception and Action: Learning from Observations, Forms of Learning, Inductive Learning, Learning Decision Trees, Ensemble Learning, Knowledge in Learning, Statistical Learning, Reinforcement Learning, Perceptional Analysis, Communication as Action	6
6	Applications of AI Techniques: Semantic Interpretation, Probabilistic Language Processing, Robotic Hardware and Software Architectures, Probabilistic Inference, Planning and Search, Localization, Tracking and Control.	6
Total lectures		42

Suggested Text Book(s):

1. Stuart J. Russel and Peter Norvig: Artificial Intelligence: A Modern Approach, Third Edition, PearsonEducation Limited, 2014.
2. E. Rich and K. Knight: Artificial Intelligence and Applications, Third Edition, Tata McGraw Hill, 2012.

Suggested Reference Book(s):

1. P. Kulkarni and P. Joshi: Artificial Intelligence, Second Edition, PHI Learning Private Limited, 2015.
2. P. H. Winston: Artificial Intelligence and Applications, Third Edition, PHI Learning Private Limited, 2017.

Other useful resource(s):

Link to topics related to course:

https://nptel.ac.in/courses/106105077/

https://nptel.ac.in/courses/106105079/

https://www.tutorialspoint.com/artificial_intelligence/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Artificial Intelligence Techniques)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	3	3	2	1	1	1	2	2	2	2	1.91
CO-2	3	3	3	3	3	2	1	1	3	2	1	3	2.33
CO-3	2	3	2	2	2	2	2	2	2	2	1	2	2.00
CO-4	3	3	3	3	2	1	1	1	2	3	2	3	2.25
Average	2.50	2.75	2.75	2.75	2.25	1.50	1.25	1.25	2.25	2.25	1.50	2.50	

Soft Computing Techniques

COURSE CODE: 18B1WEC832

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. Develop the skills to gain a basic understanding of neural network theory and fuzzy logic theory.
2. Introduce students to artificial neural networks and fuzzy theory from an engineeringperspective

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Comprehend the fuzzy logic and the concept of fuzziness and concepts of neural networks	Familiarity
CO-2	Demonstrate knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic	Assessment
CO-3	Understand appropriate learning rules for each of the architectures and learn several neural network paradigms and its applications	Assessment
CO-4	Apply fuzzy rules and neural network learning rules and design paradigms to solve engineering and other Problems.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to fuzzy set theory: Probabilistic reasoning, Fuzzy sets, mathematics of fuzzy set theory, operations on fuzzy sets, comparison of fuzzy and crisp set theory.	4
2	Fuzzy mapping: one to one mapping, max-min principle, extension principle, implication rules – mamdani implications. Membership functions: Universe of discourse, mapping inside fuzzy domain, fuzzy membership mapping methods, and application to real world problems.	10
3	Artificial Neural Networks (ANN) and their biological roots and motivations. Comparison Between Artificial and Biological Neural Networks, Applications of Neural network. Network Architecture ,Taxonomy of neural networks: feed forward and recurrent networks with. Merits and limitations of neurocomputing.	8
4	Types of learning, supervised and unsupervised learning laws . Learnig Laws : Hebb's rule, Delta rule, Widrow - Hoff (The Least-Mean-Square) learning rule, correlation learning rule, instar and outstar learning rules, Competitive learning, Credit Assignment Problem, Error Correction learning, Memory based learning.	9

5	The Perceptron and its learning law, Classification of linearly separable patterns, Multi-Layer Perceptron, Supervised Learning, Back-Propagation Learning law. Feed forward networks, Recurrent Networks.	6
6	Winner takes-all Networks, Competitive Learning, Kohonen's Self organizing Maps, Introduction to Adaptive Resonance Theory.	5
Total lectures		42

Suggested Text Book(s):

1. Simon Haykin: Artificial Neutral Networks, 2nd Edition, Pearson, 2008.
2. Yegna Narayanan: Artificial Neural Networks, 2nd Edition, Prentice-Hall of India, 2010.
3. S.N. Sivanandam, S.N Deepa: Principles of Soft Computing, 3rd Edition, Wiley, 2019.

Suggested Reference Book(s):

1. Bart Kosko: Neural Network and Fuzzy Systems: A Dynamic System Approach to Machine, Prentice-Hall 1998
2. L. Fausett: Fundamentals of Neural Networks: Architectures, Algorithms, and Applications, Prentice-Hall,Reprint 2013
3. Jack M. Zurada: Introduction to Artificial Neural Systems, PWS Publishing Co., 2nd Edition, 2002.

Other useful resource(s):

Link to NPTEL course contents

1. http://nptel.ac.in/courses/117105084/
2. http://nptel.ac.in/courses/108104049/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Soft Computing Techniques)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	2	2	2	3	2	1	1	1	2	2	2	1.92
CO-2	3	2	3	3	3	1	1	1	1	2	2	2	2.00
CO-3	3	2	3	3	3	2	1	1	1	2	2	2	2.08
CO-4	3	3	3	3	3	2	3	1	1	3	3	3	2.58
Average	3	2.25	2.75	2.75	3	1.75	1.5	1	1	2.25	2.25	2.25	2.15

Statistical Signal Processing

COURSE CODE: XXXXXXX

COURSE CREDITS: 3

CORE/ELECTIVE: Elective

L-T-P: 3-0-0

Pre-requisite: Principles of Digital Signal Processing (18B11EC511)

Course Objectives:

1. To understand signal models, signal characterization, and spectral estimation.
2. To understand, theory, implementation, and applications of statistical signal processing methods.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Able to understand the autoregressive, moving average, autoregressive moving average, and general linear models and how they relate to signal processing	Familiarity
CO-2	Able to apply wiener filter and adaptive filter for filtering and noise cancellation.	Usage
CO-3	Able to apply nonparametric techniques for spectral estimation	Usage
CO-4	Able to understand the cross-power spectral density, coherence, and apply time-frequency analysis tools for different application.	Familiarity & Usage
CO-5	Able to implement and apply these skills for different applications or projects.	Assessment

Course Contents:

S. No.	Contents	Contact Hours
1.	Introduction, Discrete-Time Processing, Discrete-Time Systems, Random Variables, Stochastic Signals, Estimation Theory, Signal Models, Autocorrelation, Windowing, IMPLEMENTATION IN PYTHON OR MATLAB	6
2	Linear Estimation, Optimum FIR Filters, Linear Prediction, Optimum IIR Filters, Optimum Linear Filter Applications, Kalman Filter, Extended Kalman Filter, Least-Squares Estimation, Implementation in PYTHON OR MATLAB.	8
3	Spectral Estimation, Non-Parametric Methods, Minimum Variance Spectrum Estimation, Maximum Entropy Method, Frequency Estimation Method, Parametric Methods, Principal Component Spectrum Estimation Method, Implementation in PYTHON OR MATLAB.	16
4	Joint Signal Analysis, Coherence Analysis, Time-Frequency Analysis, Implementation in PYTHON OR MATLAB.	8
5.	Adaptive Filtering, FIR Adaptive Filter, Implementation in PYTHON or MATLAB.	4
	Total	42

Suggested Text Book(s):

1. M. H. Hayes, Statistical Digital Signal Processing and Modelling, John Wiley & Sons, Student Edition, 2013.
2. D.G. Manolakis, V.K. Ingle and S.M. Kogon: Statistical and Adaptive Signal Processing, Artech House publishers, 2005.

Suggested Reference Book(s):

1. John G, Charles M. Algorithms for statistical signal processing. Prentice Hall, London; 2002.
2. Simon Haykin, Adaptive Filter Theory, Prentice Hall, 1996

Other useful resource(s):

1. https://nptel.ac.in/courses/108/103/108103158/#
2. http://web.cecs.pdx.edu/~ssp/
3. http://www.eas.uccs.edu/~mwickert/ece5615/lecture_notes/
4. http://www.eas.uccs.edu/~mwickert/ece5615/lecture_notes/N5615_1.pdf

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Statistical Signal Processing)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	2	2	3	3	2	3	3	3	3	3
CO-2	3	3	3	3	3	3	3	3	3	3	3	3	3
CO-3	3	3	3	3	3	2	3	3	2	3	3	3	3
CO-4	3	3	3	3	3	3	2	3	3	3	3	3	3
CO-5	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	3	3	2.8	2.8	2.8	2.8	2.8	2.8	2.8	3	3	3	

Digital Filter Design and Applications

COURSE CODE: 18B1WEC631

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Signals & Systems Course

Objectives:

1. To understand the basics and practical limitations of digital filter design.
2. To study the digital filters applications.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the basics of the digital Filters	Familiarity
CO-2	Design and analysis of the FIR filters	Usage
CO-3	Design and analysis of the IIR filters	Usage
CO-4	Understand the limitation of IIR and FIR Filters in implementation	Familiarity
CO-5	Study the applications of digital filters	Assessment

Course Contents:

S. No.	Contents	Contact Hours
1.	Introduction to Filters: Butterworth filters, Chebyshev filters, Elliptical Filters, Bessel Filters, FIR filters, IIR Filters.	10
2.	FIR Filters: One dimensional FIR filter design using rectangular window, triangular window, hamming window, dolph-chebyshev window, and Kaiser window. Two dimensional FIR filter design.	10
3	IIR Filters: One dimensional and two dimensional IIR filter design.	06
4.	Practical Considerations in implementation Coefficient Quantization in Digital Filters, Scaling in Fixed-Point Arithmetic, Quantization Noise.	04
5.	Applications of Digital Filters, Noise suppression, Enhancement of selected frequency ranges, Removal or attenuation of selected frequencies, Bandwidth limiting. Analysis of digital filters for signal and image processing using MATLAB, and LABVIEW.	12
	Total	42

Suggested Text Book(s):

1. Andreas Antoniou, Digital Filters: Analysis, Design and Applications, Second edition, Tata Mc Graw Hill, 1999.
2. M. Ahmadi, M. Azimi-Sadjadi, R. Gorgui-Naguib, R. King, A. Kwabwe,Digital Filtering in One and Two Dimensions, 1st Edition, Springer Science & Business Media, 1989.

3. Jackson, Leland B. Digital Filters and Signal Processing: with MATLAB®Exercises. Springer Science &Business Media, 2013.

Suggested Reference Book(s):

1. Wu-Sheng Lu, Two-Dimensional Digital Filters, 1st Edition, CRC Press, 2001.
2. Winder, Steve, Analog and digital filter design, 2nd Edition, Newness Publishers, 2002
3. Schaumann, Rolf, Haiqiao Xiao, and Van V. Mac. "Design of Analog Filters 2nd Edition (The Oxford Series in Electrical and Computer Engineering)." (2009).
4. C. Britton Rorabaugh, "Digital Filter Designer's Handbook: With C++ Algorithms",2nd,Volume1, McGraw-Hill, 1997
5. Jolyon M.DeFreitas, Digital Filter Design and solutions, Artech house publishers, 2005
6. Andreas Antoniou, Digital Filters: Analysis, Design and Applications, Second edition, Tata Mc Graw Hill, 1999
7. Taylor, Fred. Digital filters: principles and applications with MATLAB. Vol. 30. John Wiley & Sons, 2011.

Other useful resource(s):

1. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/video-lectures/lecture-17-design- of-fir-digital-filters/, I Prof. Alan V. Oppenheim
2. http://web.stanford.edu/class/archive/ee/ee264/ee264.1072/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Digital Filter Design and Applications)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	2	2	1	1	1	1	3	1	1	1.8
CO-2	3	3	3	3	3	1	1	1	2	2	2	2	2.2
CO-3	3	3	3	3	3	1	1	1	2	2	2	3	2.3
CO-4	3	3	3	3	3	3	3	3	3	2	2	2	2.8
CO-5	3	3	3	3	3	3	3	3	3	2	2	1	2.7
Average	3	3	3	2.8	2.8	1.8	1.8	1.8	2.2	2.2	1.8	1.8	

Time-Frequency Analysis and Applications

COURSE CODE: 18B1WEC738

COURSE CREDITS: 3

CORE/ELECTIVE: Elective

L-T-P: 3-0-0

Pre-requisite: Signals and

Systems Course Objectives:

1. Study and analyze various spectral analysis and time-frequency analysis tools.
2. Study the time-frequency analysis tools based algorithm for different applications.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the concept of the spectral analysis.	Familiarity
CO-2	Familiar with the basics concept of the short time Fourier transform /continuous wavelet transform.	Assessment
CO-3	Understand the basic concept of the distribution based Time-Frequency Analysis tools.	Assessment
CO-4	Develop the TFA based algorithms for various applications.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to spectral analysis: Parametric and Non-Parametric methods.	6
2	Basics of Time Frequency Analysis: Basic Concepts & Definition, Duration-Bandwidth Principle, Joint Energy Density, Short-time FT, its Properties & Applications, MATLAB based implementation of STFT	6
3	Wavelet transforms: Continuous Wavelet Transform and its Computational aspects, Scale to Frequency conversion, Scalogram, Scaling Function and Wavelets, Applications of CWT, MATLAB based implementation of wavelet transform.	8
4	Distributions based time-frequency tools: Wigner-Ville Distributions, Interference in WVD, its Applications, Cohen's class, Smoothed WVD, Ambiguity Functions, Affine Class, and MATLAB based implementation of distribution based time-frequency analysis tools.	8
5	Case studies: Radar and Sonar, Economic Data Analysis with the Gabor Spectrogram, Gabor Spectrogram in Ultrasonic Nondestructive Materials testing, Applications of Time-Frequency Analysis in spectrum sensing, Biomedical signal processing, Genomics data analysis.	14
Total lectures		42

Suggested Text Book(s):

1. Hayes MH. Statistical digital signal processing and modeling. John Wiley & Sons; 2009.
2. Boashah B. Time-frequency signal analysis and processing: a comprehensive reference. Academic Press; 2015.

Suggested Reference Book(s):

1. S. Mallat, A Wavelet Tour of Signal Processing - The Sparse Way. Elsevier, Third Edition, 2009.
2. Cohen, Leon, Time-frequency analysis. Vol. 778. Prentice hall, 1995.
3. Chen, Victor C., and Hao Ling. Time-frequency transforms for radar imaging and signal analysis. Artech house, 2002.

Other useful resource(s):

1. http://nptel.ac.in/courses/117101001/: The lecture series on Wavelets and Multi-rate Digital Signal Processing created by Prof. Vikram M. Gadre in NPTEL.
2. Time-frequency toolbox (MATLAB) is available for download from http://tftb.nongnu.org/
3. http://nptel.ac.in/courses/117101001/1

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Time-Frequency Analysis and its Applications)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	2	2	2	1	1	1	1	3	3	3	2
CO-2	2	3	3	3	3	1	1	1	2	3	3	3	2.3
CO-3	3	3	3	3	3	1	1	1	2	3	3	3	2.4
CO-4	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	2.5	3	2.75	2.75	2.75	1.5	1.5	1.5	2	3	3	3	

Wavelets and Applications

COURSE CODE:

COURSE CREDITS:

CORE/ELECTIVE: ELECTIVE

L-T-P: -3-0-0

Pre-requisite: Linear Algebra, Digital Signal Processing. Course Objectives:

1. To introduce students to wavelet techniques and its types.
2. To enable students to apply wavelets in various engineering applications

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the basics of wavelet transforms and compare it with Fourier transform.	Familiarity
CO-2	To construct various wavelet bases and know how to use them as a tool for analyzing functions.	Assessment
CO-3	Be familiar with multi-resolution analysis.	Familiarity
CO-4	Implement discrete wavelet transforms with multi-rate digital filters.	Assessment
CO-5	Design certain classes of wavelets to specification and justify the basis of the application of wavelet transforms to different fields.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Stationary and non-stationary signals, Signal representation using basis and frames, Brief introduction to Fourier transform and Short time Fourier transform, Time-frequency analysis, Bases of time frequency: orthogonal, Filter banks, Multi resolution formulation: Wavelets from filters, Classes of wavelets: Haar, Daubechies, bi-orthogonal.	7
2	Continuous Wavelet Transform: Continuous wavelet transform (CWT), Time and frequency resolution of the continuous wavelet transform, Construction of continuous wavelets: Spline, orthonormal, bi-orthonormal, Inverse continuous wavelet transform, Redundancy of CWT, Zoom property of the continuous wavelet transform, Filtering in continuous wavelet transform domain.	8
3	Discrete Wavelet Transform and Filter Banks: Orthogonal and biorthogonal two-channel filter banks, Design of two-channel filter banks, Tree-structured filter banks, Discrete wavelet transform, Non-linear approximation in the Wavelet domain, multi resolution analysis, Construction and Computation of the discrete wavelet transform, the redundant discrete wavelet transform	8

4	Multi Resolution Analysis: Multirate discrete time systems, Parameterization of discrete wavelets, Bi-orthogonal wavelet bases, Two dimensional, wavelet transforms and Extensions to higher dimensions, wave packets	7
5	Applications: Signal and Image compression, Detection of signal changes, analysis and classification of audio signals using CWT, Wavelet based signal de-noising and energy compaction, Wavelets in adaptive filtering, Adaptive wavelet techniques in signal acquisition, coding and lossy transmission, Digital Communication and Multicarrier Modulation, Trans multiplexers , Image fusion, Edge Detection and object isolation.	12
Total lectures		42

Suggested Text Book(s):

1. S. Mallat, "A Wavelet Tour of Signal Processing", 3rd Ed., Academic Press, Elsevier, Dec. 2008.
2. Raghuveer Rao and Ajit S. Bopardikar, "Wavelet transforms: Introduction, Theory and applications", PearsonEducation Asia, 2000.

Suggested Reference Book(s):

1. J.C. Goswami and A. K. Chan, "Fundamentals of Wavelets: Theory, Algorithms, and Applications", 2nd ed., Wiley, 2011.
2. Michel Misiti, Yves Misiti, Georges Oppenheim, Jean Michel Poggi, "Wavelets and their Applications", John Wiley & Sons, 2010.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/117/101/117101001/
2. MIT link: https://ocw.mit.edu/courses/mathematics/18-327-wavelets-filter-banks-and-applications-spring-2003/lecture-notes/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (1) - 5 Quizzes (2) - 15 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course Outcomes (Principles of Communication Systems)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	1	2	1	2	1	2	2	3	2.17
CO-2	3	3	3	3	3	2	2	2	1	1	1	3	2.25
CO-3	3	3	3	3	2	3	3	2	1	2	3	3	2.58
CO-4	3	3	3	2	2	1	1	1	1	2	3	3	2.08
CO-5	3	3	3	2	3	2	1	2	1	2	3	3	2.33
Average	3.00	3.00	3.00	2.60	2.20	2.00	1.60	1.80	1.00	1.80	2.40	3.00	

Adaptive Signal Processing and Machine Intelligence

COURSE CODE: XXXXXXXX

COURSE CREDITS: XX

CORE/ELECTIVE: XX

: XX

Pre-requisite: Prerequisites are some prior knowledge to signals and systems, basics of digital signal processing and machine learning. Student should have a basic level of expertise in programming and mathematics.

Course Objectives:

1. To understand the fundamentals of statistical properties of complex-valued and multidimensional signals
2. Algorithms and applications of adaptive signal processing to real-time streaming data
3. Become familiar with learning algorithms for multidimensional signals
4. To study State of the Art machine learning algorithms in real time signal processing applications.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Gain in-depth understanding of adaptive signal processing algorithms	Familiarity
CO-2	Examine statistical properties and performance of these algorithms in real-world applications.	Assessment
CO-3	Apply adaptive learning algorithms for multidimensional signals	Assessment
CO-4	Study of real world case studies and applications	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Review of orthogonal transforms: DFT, DCT and Haar, Properties of DFT, Computation of DFT: FFT and structures, Decimation in time, Decimation in frequency, Linear convolution using DFT, Basic FIR/IIR filter structures, FIR/IIR Cascaded lattice structures, Parallel all pass realization of IIR transfer functions, Computational complexity of filter structures	8
2	Basics of Adaptive Signal Processing: Linear algebra and random processes, Optimal estimation, Linear estimation. Steepest-descent algorithms. Stochastic-gradient algorithms. Kalman filtering. Particle filtering. Blind de-convolution and beam forming, Robust adaptive filters, Adaptive filters, Least Mean Squares algorithm	8
3	Machine Learning for Signal Processing: Distance based signal classification, nearest neighbor classifier, Hilbert space, Linear systems,	7

	circulant matrices, convolution, eigenvector decomposition using SVD, Bayes classifiers based signal detection, dimensionality reduction using PCA	
4	Kernel based Machine Learning for Signal Processing: Review of support vector machine (SVM), Classification and Regression using SVM, Properties of Kernels, Non-Mercer Kernels, Kernel Selection, Multiple Kernel Learning, Kernel features	7
5	Deep Neural Network for Signal Processing: Nonlinear learning algorithms and architectures, such as dynamical perceptrons, feedforward and recurrent neural networks, and their connection with general neural networks and deep learning. Tensors for Big Data applications	6
6	Applications in Real World Domain: Transfer Learning, Dictionary learning, Attention models, Attribute-based learning, Deep learning for wireless applications, speech and image processing, sparse signal processing and compressive sensing for machine learning.	6
Total lectures		42

Suggested Reference Book(s):

1. C.M. Bishop, "Pattern Recognition and Machine Learning", 2nd Edition, Springer, 2011.
2. D. Yu and L. Deng, "Automatic Speech Recognition: A Deep Learning Approach" , Springer, 2016.
3. I. Goodfellow, Y, Bengio, A. Courville, "Deep Learning", , MIT Press, 2016.

Other useful resource(s):

1. http://home.iitk.ac.in/~vipular/stuff/2019_MLSP.html
2. http://web.stanford.edu/class/ee269/index.html
3. http://intranet.ee.ic.ac.uk/electricalengineering/eecourses_t4/course_content.asp?c=EE4-13&s=D4

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Adaptive Signal Processing and Machine Intelligence)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	3	3	2	1	1	1	2	2	2	2	1.91
CO-2	3	3	3	3	3	2	1	1	3	2	1	3	2.33
CO-3	2	3	2	2	2	2	2	2	2	2	1	2	2.00
CO-4	3	3	3	3	2	1	1	1	2	3	2	3	2.25
Average	2.50	2.75	2.75	2.75	2.25	1.50	1.25	1.25	2.25	2.25	1.50	2.50	

Bio Electronics Sensors

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Analog Electronics

Course Objectives:

1. To study transducers and sensors (bio sensors)
2. to study bio-potentials, bio-electrodes and bio-signal amplifiers

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Gain knowledge on sensors, actuators and transducers	Familiarity
CO-2	Learn to design circuits of bio-sensor for electrical and nonelectrical signals	Usage
CO-3	Acquaint with different types of amplifiers used for biosensors	Familiarity
CO-4	Learn about bio-potential and bio-potential amplifiers	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Introduction to Sensor, Bio electronics, Bioelectronics Sensor, Systems biology and Synthetic biology	4
2	Electrodes, Sensors and transducers: Sensor/Actuators, Active v/s passive sensors, sensor error sources, sensor terminology, Types of Sensors, Bio sensor, Block diagram of Bio-sensor for electrical and non electrical signals, electrodes for biophysical sensing, transducers, performance parameters of sensors, complete circuit diagram of bio sensor.	8
3	Bio-potential Electrodes: The electrode-electrolyte interface, polarization, polarizable and non-polarizable electrodes, Electrode behavior and circuit models, body surface recording electrodes, internal electrodes, micro electrode, macro electrode	4
4	Bio-electric Amplifiers: Voltage, current, power amplifiers, Low gain, medium gain, high gain amplifiers	6
5	Bio-potentials: ECG, EEG, EMG, ERG, EOG, its amplitude and bandwidth, Electrodes for Bio-potential Recordings, Electrical Interference Reduction.	6
6	Bio-potential Amplifiers: Operational amplifiers, basic amplifier configurations, multiple input circuits, differential amplifiers, signal processing circuits, isolation amplifiers, IMRR, ECG Amplifier, functional block, interference from electric devices, transient protection, common mode and other interference reduction circuits, Driven right leg circuit, amplifiers	8

	for other bio-potential signals, pre amplifier.	
7	Bio-signal Amplifiers : Instrumentation amplifier, Chopper Amplifier, Carrier Amplifier	6
Total lectures		42

Suggested Text Book(s):

1. Carr, J. J., Brown, J. .M., "Introduction to Biomedical Equipment Technology," 4th Ed, Pearson, 2001.
2. Reddy, D. D., Hussian, O.M., Gopal, D.V. R., Rao, D. M., Sastry, K.S. "Biosensors and Bioelectronics," I.K. International Pub., 2012
3. Gayakwad, R. A., "Op-amps and Linear Integarted Circuits," 4th Ed., PHI, 2000.
4. Klir, G. J., Yuan, B, "Fuzzy Sets and Fuzzy Logic," PHI. Pearson, 1995.

Suggested Reference Book(s):

1. Webster JG (Ed.), "Medical Instrumentation, Application and Design," 4th Ed., John Wiley & Sons, 2016.
2. Chatterjee S and Miller A, "Biomedical Instrumentation Systems," Cengage Learning, 2018

Other useful resource(s):

1. NPTEL ONLINE COURSES NPTEL: Biomedical Signal Processing. https://nptel.ac.in/courses/108105101/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course Outcomes (Bio Electronics Sensors)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO1	3	3	2	1	1	2	X	X	X	X	X	2	1.17
CO2	3	3	3	2	2	2	X	X	1	2	2	3	1.92
CO3	3	3	2	1	1	2	X	X	X	1	1	3	1.42
CO4	3	3	2	2	1	2	X	X	X	1	1	3	1.50
Average	3.00	3.00	2.25	1.50	1.25	2.00	0.00	0.00	0.25	1.00	1.00	2.75	

Fundamentals of Digital Image Processing and Applications

COURSE CODE: 20B1WEC533

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

: 3-0-0

Pre-requisite:

Course Objectives:

1. **Describe and explain basic principles of digital imageprocessing.**
2. Design and implement algorithms that perform basic image processing.
3. Design and implement algorithms for advanced image analysis.
4. Assess the performance of image processing algorithms andsystems.

Course Outcomes

This course provides the knowledge of analog and digital communication system analysis and design. After study through lectures and assignments, students will be able to

S. No.	Course Outcomes	Level of Attainment
CO-1	Analyze general terminology of digital image processing.	Familiarity
CO-2	Examine various types of images, intensity transformations and spatial filtering.	Usage
CO-3	Evaluate the methodologies for image segmentation, restoration etc.	Usage
CO-4	Understand different types of medical imaging modalities and would be able to differentiate them with respect to their advantages and limitations.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Digital Image Fundamentals: Fundamental steps in DIP, Components of digital image processing, elements of visual perception, Structure of the human eye, Image formation in the eye, Brightness adaptation and discrimination, light, Image sensing and acquisition, image formation model, definition and some properties of two dimensional system, Discrete 2D convolution, 2D discrete Fourier transform and its properties, optical and modulation transfer function, Spectral density function. Sampling and quantization of images, Two dimensional sampling theory, representation of digital image, Spatial and gray level resolution, zooming and shrinking, some basic relationships between pixels.	7

2	Image Enhancement in the Spatial Domain: Gray Level Transformations, Piecewise linear transformation, Histogram Processing, Enhancement Using Arithmetic/Logic Operations. Basics of Spatial Filtering, Smoothing and Sharpening Spatial Filters, Use of first order and second order derivative in enhancement.	7
3	Image Enhancement in the Frequency Domain: Two dimensional Fourier Transform, properties of frequency domain, correspondence between filtering in spatial and frequency domain, Smoothing and Sharpening frequency domain filters, Homomorphic Filtering.	7
4	Image Restoration: Model of the Image Degradation/Restoration Process, Noise Models, Noise reduction in spatial domain and frequency domain, Inverse filtering, Wiener filtering.	7
5	Image Segmentation: Detection of Discontinuities (point, line edge), Edge Linking and Boundary Detection, Thresholding, Basic global Thresholding, Adaptive Thresholding, Region-Based Segmentation, region growing, splitting and merging.	7
6	Application of Image Processing In Medical Field: Working principle, applications and limitations of different medical imaging modalities. Types of texture parameters: Statistical analysis of texture (First order statistics and Second order statistics), Grey level co-occurrence matrix, grey-level run length matrix.	7
Total lectures		42

Text Books

1. R.C.Gonzalas and R.E.Woods, Digital Image Processing, Prentice Hall, 3rd Ed.
2. Rangaraj M. Rangayyan: Biomedical Image Analysis, 1st Ed., CRC Press, New York , 2004.

Reference Books

1. A.K.Jain, Fundamentals of Digital Image Processing, PrenticeHall.
2. S.Sridhar, Digital Image Processing, Oxford UniversityPress.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus

4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Fundamentals of Digital Image Processing & Applications)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	3	2	3	1	2	1	2	2.42
CO-2	3	3	3	3	2	0	0	1	2	3	1	1	1.83
CO-3	3	3	3	3	3	1	1	1	1	2	1	1	1.92
CO-4	3	3	3	3	3	3	2	3	2	2	3	3	2.75
Average	3.00	3.00	3.00	3.00	2.75	1.75	1.25	2.00	1.50	2.25	1.50	1.75	

Computer Vision

COURSE CODE: XXXXXXXX

COURSE CREDITS: XX

CORE/ELECTIVE: XX

: XX

Pre-requisite: Prerequisites are some prior knowledge to computer vision, machine learning and image processing. Student should have a basic level of expertise in programming, computer science, and mathematics.

Course Objectives:

1. To implement fundamental image processing techniques required for computer vision.
2. Understand image formation process.
3. Extract features form Images and generate 3D model from images.
4. To study State of the Art algorithms with engineering applications.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Theoretical and practical aspects of computing with images	Familiarity
CO-2	The foundation of image formation and image analysis	Assessment
CO-3	Understand the basics of 2D and 3D Computer Vision	Assessment
CO-4	Study of computer vision applications	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction : Image Processing, Computer Vision and Computer Graphics Overview of Diverse Computer Vision Applications: Document Image Analysis, Biometrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing, Multimedia, Virtual Reality and Augmented Reality	8
2	Image Formation Models : The 'Physics' of Image Formation, Radiance, Irradiance, BRDF, color etc, Camera model and Camera calibration, Binocular imaging systems, Multiple views geometry, Structure determination, shape from shading, Photometric Stereo, Depth from Defocus, Construction of 3D model from images	8
3	Feature Extraction and Motion Estimation: Image preprocessing, Image representations (continuous and discrete), Edge detection, Regularization theory, Stereo Vision, Motion estimation, Structure from motion	7

4	Shape Representation and Segmentation : Contour based representation, Region based representation, Deformable curves and surfaces, Snakes and active contours, Level set representations, Fourier and wavelet descriptors, Multi resolution analysis	7
5	Object recognition: Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal component analysis, Singular value decomposition.	6
6	Applications: Face detection, Face recognition, Eigen faces, Active appearance and 3D shape models of faces Application, Applications range from Biometrics, Medical diagnosis, document processing, mining of visual content, to surveillance, advanced rendering etc.	6
Total lectures		42

Suggested Text Book(s):

1. D. Forsyth and J. Ponce, "Computer Vision - A modern approach, by ", Prentice Hall
2. B. K. P. Horn, "Robot Vision", McGraw-Hill.
3. R. C. Gonzalez, R. E. Woods, " Digital Image Processing" Addison Wesley Longman, Inc., 1992
4. D. H. Ballard, C. M. Brown, "Computer Vision", Prentice-Hall, Englewood Cliffs, 1982.

Suggested Reference Book(s):

1. Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 2012
2. Mark Nixon and Alberto S. Aquado, "Feature Extraction & Image Processing for Computer Vision", Third Edition, Academic Press, 2012.

Other useful resource(s):

1. Computer Vision. Ballard and Brown
2. Invitation to 3D Vision: From Images to Geometric Models: Y. Ma, S. Soatto, J. Kosecka and S. Sastry
3. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cs58/
4. https://www.tutorialspoint.com/dip/computer_vision_and_graphics.htm

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Computer Vision)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	3	3	2	1	1	1	2	2	2	2	1.91
CO-2	3	3	3	3	3	2	1	1	3	2	1	3	2.33
CO-3	2	3	2	2	2	2	2	2	2	2	1	2	2.00
CO-4	3	3	3	3	2	1	1	1	2	3	2	3	2.25
Average	2.50	2.75	2.75	2.75	2.25	1.50	1.25	1.25	2.25	2.25	1.50	2.50	

Forensic Image Processing

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Prerequisite: Fundamentals of Digital Image Processing

Course Objectives:

1. To aware the students about the role of image processing for forensic investigations.
2. To introduce different attributes of the image source that helps in the identification of the source of the image.
3. To make students understand the role of watermarking, cryptography and other methods used for forensic investigation.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understand the requirement of image processing in Image processing	Familiarity
CO-2	Understand the working of digital image capturing devices and parameters related to the devices.	Usage
CO-3	Understand the attributes of the image source for forensic investigation.	Usage
CO-4	Able to implement watermarking and cryptography methods on images.	Assessment
CO-5	Able to compare the two images and identify the content present in them.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Forensic image analysis: A Framework and its applications (Example of Police cases solved with forensic image processing)	3
2	Digital Still and Video Cameras: Dynamic Range, Light and Lenses, Setting exposure, Resolution, File format and compressions, JPEG and MPEG compression	7
3	Image Enhancement and Restoration: Color Spaces, Color Correction, Interpol tion, Convolutions, Enhancement Filters, Morphological Filters, Sharpening Contrast	8
4	Techniques attributing an image to its source: Image and Video source class identification, Sensor defects in digital image forensic	8
5	Detecting doctored images: Digital Watermarking and cryptography	8

6	Photo Image Comparison, Image Content Analysis, Image Authentication	8
Total lectures		42

Suggested Text Book(s):

1. Sencar, Husrev Taha, Memon, Nasir (Eds.), "Digital Image Forensics: There is More to a Picture than Meets the Eye", Springer, 2012.

Suggested Reference Book(s):

1. Anthony T. S. Ho, Shujun Li, "Handbook of Digital Forensics of Multimedia Data and Devices", Wiley 2016.
2. Ahmed Bouridane, "Imaging for Forensics and Security", Springer, 2009

Other useful resource(s):

1. Judith A. Redi, Wiem Taktak & Jean-Luc Dugelay, "Digital image forensics: a booklet for beginners", Multimedia Tools and Applications volume 51, pages133–162, 2011.
2. NPTEL online course: https://www.youtube.com/watch?v=O2RwWHWHQlM

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	3	2	2	2	2	2	x	x	2	2	2	2.1
CO2	2	3	2	2	2	2	2	x	x	2	2	2	2.1
CO3	3	3	3	3	3	2	2	x	3	2	2	2	2.54
CO4	3	3	3	3	3	2	2	x	3	2	2	2	2.54
CO5	3	3	3	3	3	2	2	x	3	2	2	2	2.54
Average	2.6	3	2.6	2.6	2.6	2	2	x	3	2	2	2	

Medical Image Processing

COURSE CODE: 18B1WEC836

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To introduce various medical imaging modalities.
2. To teach the requirement and development of different blocks of computer aided diagnosis for medical images.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Able to understand different types of medical imaging modalities and would be able to differentiate them with respect to their advantages and limitations.	Familiarity
CO-2	Acquire an ability to analyze and process medical images.	Usage
CO-3	Understand different feature extraction techniques and classifiers used for image classification.	Usage
CO-4	Understand the role of computer aided diagnosis for medical images.	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Image Processing:- Acquisition of Images, Image Sampling and quantization; Spatial and histogram based enhancement; Noise modeling, Image restoration. Image transformation.	8
2	Edge Detection and Image Segmentation: Gradient based edge detectors. Intensity thresholding based image segmentation; Region growing and region splitting algorithm; watershed segmentation.	8
3	Medical Imaging Modalities: Working principle, applications and limitations of Computed tomography , X-ray, Magnetic resonance imaging, Ultrasound imaging, and Positron emission tomography; Various Artifacts.	6
4	Image Texture: Types of texture parameters: Statistical analysis of texture (First order statistics and Second order statistics), Grey level co-occurrence matrix, grey-level run length matrix.	8
5	Pattern classification: Supervised and Unsupervised pattern classification, Neural Network classifier, Support Vector Machines.	6

6	Case Studies: Pre-processing, Segmentation, Feature extraction, and Classification of medical images.	6
Total lectures		42

Suggested Text Book(s):

1. Chris Solomon, Toby Breckon: Fundamental of Digital Image Processing, 1st Ed., John Wiley & Sons, 2011.
2. Rangaraj M. Rangayyan: Biomedical Image Analysis, 1st Ed., CRC Press, New York , 2004.

Suggested Reference Book(s):

1. RC Gonzalez, RE Woods, Digital Image Processing, 3rd Ed., Pearson Publisher, 2008.
2. Kayvan Najarian, Robert Splinter: Biomedical Signal and Image Processing, 2nd Ed., CRC Press, 2012
3. Tamal Bose: Digital Signal and Image Processing, 1st Ed., John Wiley & Sons, 2003.

Other useful resource(s):

1. http://www.nptelvideos.in/2012/12/digital-image-processing.html (Prof P.K. Biswas, IIT Kharagpur)

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Medical Image Processing)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	3	2	3	1	2	1	2	2.42
CO-2	3	3	3	3	2	0	0	1	2	3	1	1	1.83
CO-3	3	3	3	3	3	1	1	1	1	2	1	1	1.92
CO-4	3	3	3	3	3	3	2	3	2	2	3	3	2.75
Average	3.00	3.00	3.00	3.00	2.75	1.75	1.25	2.00	1.50	2.25	1.50	1.75	

Applied Medical Signal Processing

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To introduce different biomedical signals.
2. To apply different methods to analyze and filter the signals.
3. To detect events in signals used for diagnosis.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Identify and reproduce signal processing methods used in forefront biomedical sciences	Familiarity
CO-2	Able to filter out the noise and artifacts from the medical signals.	Usage
CO-3	Critically assess the appropriateness of biomedical signal processing techniques for various problems in the field	Usage
CO-4	Evaluate the effectiveness of techniques applied to biomedical signals against specific benchmarks	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Preliminaries, Medical signal origin & dynamics (ECG, EEG, EMG etc.)	4
2	Filtering for removal of artifacts: Statistical Preliminaries, Time domain filtering (Synchronized Averaging, Moving Average, Derivative-based operator), Frequency Domain Filtering (Notch Filter), the Weiner Filter, Adaptive Filter and related design problems.	12
3	Waveform Analysis: Illustrations of problem with case studies, Morphological analysis, transform analysis, correlation coefficient, Periodogram, Averaged periodogram, Blackman-Tukey Spectral Estimator, Daniell's Spectral Estimator, Measures derived from PSD	9
4	Modeling of Biomedical Systems: Motor unit firing pattern, Autoregressive model, Autocorrelation method, Parametric modeling, Levinson-Durbin algorithm, Covariance method, Spectral matching and parameterization, Model order selection	12

5	Pattern classification and diagnostic decision: Illustrations of problem with case studies, Feature extractions from medical signals, supervised and unsupervised pattern classification, Reliability of features, classifiers and decisions.	5
Total lectures		42

Suggested Text Book(s):

1. Rangaraj M. Rangayyan, Biomedical Signal Analysis, 2nd Ed., Wiley, 2015.
2. Willis J. Tompkins , Biomedical Digital Signal Processing, 10th Ed., Prentice Hall, 2011
3. D C Reddy, Biomedical Signal Processing: Principles and Techniques, 1st Ed., Tata McGraw-Hill Publishing Co. Ltd, 2005
4. J G Webster, Medical Instrumentation: Application & Design, 3rd Ed. John Wiley & Sons Inc., 2007

Suggested Reference Book(s):

1. R. S Khandpur and Raghbir Khandpur: Biomedical Instrumentation, 2nd Ed., McGraw-Hill Education , 2003.
2. Leslie Cromwell, Fred Weibell J, Erich Pfeiffer. A: Biomedical Instrumentation and Measurements, Prentice-Hall India, 2nd Edition, 1997.
3. C Raja Rao, S K Guha, Principles of Medical Electronics and Biomedical Instrumentation, 1st Ed., Universities Press, 2001

Other useful resource(s):

Link to NPTEL course contents:

1. https://nptel.ac.in/courses/108105101/
2. https://onlinecourses.nptel.ac.in/noc19_ee23/preview

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Applied Medical Signal Processing)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	1	3	2	3	2	2	3	2	2	1	3	2.28
CO-2	3	3	3	3	3	1	1	2	2	2	1	3	2.25
CO-3	3	3	3	3	3	1	1	2	2	2	1	3	2.25
CO-4	3	3	3	3	3	1	1	2	2	2	1	3	2.25
Average	2.75	2.5	3	2.75	3	1.25	1.25	1.25	2	2	1	3	

Remote Sensing and Satellite Image Processing

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: Elective

L-T-P: 3-0-0

Pre-requisite: None.

Course Objectives: To provide basic understanding about satellite based Remote Sensing and analyses Satellite Image Processing techniques.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To lay foundations in understanding the concepts of remote sensing.	Familiarity
CO-2	To lay foundations in analyzing the images obtained from satellites	Usage
CO-3	To apply the theoretical knowledge acquired to various applications.	Usage
CO-4	To understand about different imaging techniques and their applications	Familiarity and Usage

Course Contents:

S. No	Topics	Classes
1	Remote Sensing: Basics of Remote Sensing: Overview of Remote sensing: Definition of Remote sensing, Principles of Remote Sensing, Electromagnetic Radiation, Radiometric terms and definitions, Radiation Laws, EM spectrum, Sources of EM, Interaction of EM Radiation with atmosphere, and target, Atmospheric Widows, imaging spectrometry, Spectral signature of various land cove features Platforms and sensors: Platforms: Types of platforms, ground, airborne, and space born platforms, Orbit of satellites, Kepler's Law, satellite characteristics, satellites for Earth observations studies, and planetary missions (Chandrayana) Sensors: Types and classification of sensors, imaging modes, Characteristics of optical sensors, sensor resolution-spectral, radiometric and temporal, Characteristics of detectors.	8
2	Data reception, Data processing & Data generation: Ground station, Data generation, Data processing & correction, Radiometric and Geometric corrections, Radiometric corrections, Random noise correction, Atmospheric correction, Geometric errors and corrections, Distortion evaluated from tracking data, distortion evaluated from ground control Image correction. Ground Investigation in support of Remote sensing, Uses of ground data, calibration correction, Interpretation of properties, Training sets, Accuracy evaluation, test	8

	sites, Ground truth Instruments and spectral signature, Spectral Reflectance and spectral signature of vegetation, Sources of RS data: Global and Indian data products	
3	Visual Image Interpretation: Introduction to Visual Interpretation, Basic principles of Visual Interpretation, Elements of Visual Interpretation, Techniques of Visual Interpretation, Interpretation Keys, Methods of searching and sequence of Interpretation, Methods of analysis and Reference levels, Computer compatible tapes – Band sequential format, Band interleaved by Line format, Run-length encoding format. Hardcopy outputs – Generation of B/W and False Color Composites. Generally supported scales of the data products, Information about annotation of the products.	9
4	Thermal Imaging system: Thermal Imaging System: Introduction - IR region of the Electromagnetic spectrum, Atmospheric transmission, Kinetic and radiant temperature, Thermal properties of materials, Emissivity, Radiant temperature. Thermal conductivity. Thermal capacity, thermal inertia, apparent thermal inertia, Thermal diffusivity. Radiation principles (Plank's Law, Stephen Boltzman law), Interaction of EMR with earth surface, Wien's displacement law, Kirchoffs Law).IR - radiometers, Airborne and Satellite TTR scanner system Characteristics of IR images, Scanner distortion, image irregularities, Film density and recorded ,Temperature ranges, Effects of weather on images, Clouds, Surface winds, Penetration of smoke plumes, Interpretation of thermal imagery, Advantages of Thermal imagery	9
5	Microwave Remote Sensing: Introduction - Electromagnetic spectrum, Airborne and Space borne radar systems basis instrumentation. System parameters - Wave length, Polarization, Resolutions, Radar geometry. Target parameters - Back scattering, Point target, Volume scattering, Penetration, Reflection, Bragg resonance, Cross swath variation. Speckle radiometric calibration. Microwave sensors and Image characteristics, Microwave image interpretation, Application : Geology, Forestry, Land use, Soils etc. Future trends and Research, Physics of lager, laser interaction with objects. Types of LiDAR, platforms of LiDAR, components of LiDAR.	8

Suggested Text Book(s):

1. Sabins Jr, Floyd F. *Remote sensing--principles and interpretation*. WH Freeman and company, 1987.
2. Lillesand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. *Remote sensing and image interpretation*. John Wiley & Sons, 2015.
3. Davis, Shirley M., et al. "Remote sensing: the quantitative approach." *mhi* (1978).
4. Jensen, John R. *Introductory digital image processing: a remote sensing perspective*. No. Ed. 2. Prentice-Hall Inc., 1996.
5. Trevett, J. William. *Imaging radar for resources surveys*. Springer Science & Business Media, 2013.

Suggested Reference Book(s):

1. Mather, Paul M., and Magaly Koch. *Computer processing of remotely-sensed images: an introduction*. John Wiley & Sons, 2011.
2. Schowengerdt, Robert A. *Remote sensing: models and methods for image processing*. Elsevier, 2006.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/courses/105/108/105108077/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Optimization Techniques)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	1	1	1	2	1	2	1.7
CO-2	2	3	2	3	2	2	1	1	1	2	1	2	1.8
CO-3	3	3	3	3	3	2	1	1	1	2	1	2	2.1
CO-4	2	2	2	2	2	2	1	1	1	3	1	2	1.8
Average	2.25	2.5	2.25	2.5	2.25	2.0	1.0	1.0	1.0	2.25	1.0	2.0	

RF Integrated Circuits

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives: This course will develop electronic circuits for radio frequency applications, specific to CMOS integrated circuits

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Introduction to CMOS integrated circuits specific to radio frequencies.	Familiarity
CO-2	Design of circuits for radio frontends for mobile phone handsets.	Usage
CO-3	Learn to design low noise amplifiers and mixer circuits.	Usage
CO-4	Applications of voltage controlled oscillators and phase locked loops, power amplifier in the design of modern radio architecture.	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	Introduction:RF systems-basic architectures, Transmission media and reflections, Maximum power transfer, Passive RLC Networks:Parallel RLC tank, Series RLC networks, matching, Pi match, T match, MOS device review	6
2.	Passive IC components: Resistors, capacitors, inductors, wires and transmission lines	6
3.	High Frequency Amplifier Design: Bandwidth estimation using open-circuit time constants, Bandwidth estimation using short-circuit time constants, Rise time, delay and bandwidth, Zeros to enhance bandwidth, Shunt-series amplifiers, tuned amplifiers, Cascaded amplifiers. Noise: Thermal noise, flicker noise review, Noise figure, phase noise general consideration	7
4.	Low noise amplifiers and Mixer design: Intrinsic MOS noise parameters, Power match versus noise match, Large signal performance, Multiplier based mixers, multiplier fundamentals, Subsampling mixers	6
5.	Voltage controlled oscillator: A tank based oscillators, phase in oscillators, Resonators, Negative resistance oscillators,	5

6.	Phase locked loops:Phase locked loop basics, charge pump, PLL dynamics integer, Spurious frequencies fractional and synthesis, Fractional spurs, Delta and sigma modulation	6
7.	RF Power Amplifiers: Class abc power amplifiers, Class bcd power amplifiers and Class cd pwm amplifiers	6
Total lectures		42

Suggested Text Book(s):

1. T. H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits", Cambridge University Press, 2004.
2. B. Razavi, "RF Microelectronics", Prentice Hall, 1997
3. B. Christopher, "RF circuit design", Elsevier, 2011

Other useful resource(s):

1. NPTEL online course: https://nptel.ac.in/courses/117/102/117102012

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course Outcomes (RF Integrated Circuits)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO1	2	1	3	3	3	2	1	1	1	1	1	1	1.67
CO2	3	3	3	2	2	2	1	1	3	3	2	3	2.33
CO3	3	3	3	3	2	2	1	1	3	2	2	3	2.33
CO4	3	3	3	3	2	2	1	1	3	2	2	2	2.25
Average	2.75	2.50	3.00	2.75	2.25	2.00	1.00	1.00	2.50	2.00	1.75	2.25	

Fundamentals of Computational Electromagnetics

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

Computational techniques are used for practical applications in electromagnetic fields, devices, scattering, propagation, and radiation. Techniques like method of moments, finite difference method, finite element method, physical optics, and hybrid methods form the background of various electromagnetic solvers.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Student will be able to identify the best numerical method to simulate a given device.	Familiarity
CO-2	Students will be able to solve scattering problems and antenna radiation/impedance calculation problems	Usage
CO-3	The student will be able to formulate and implement the finite-difference method.	Usage
CO-4	The student will be able to formulate and implement finite volume method.	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	Introduction: Introduction to transmission lines, uniform plane waves, plane waves at Media interface, Microwave waveguide: Rectangular waveguide and circular waveguide.	9
2.	FDM - Finite Difference Method: Background, Finite differencing, Accuracy, Dispersion, Stability, Maxwell PDE System, Maxwell FDTD System, Maxwell FDFD System, Boundary conditions: Introduction Absorbing Boundary Conditions (ABCs).	9
3.	Variational Method: Background, Calculus of Variations, variational methods: Rayleigh-Ritz Method, Method of weighted residuals, Galerkin Method	6
4.	FEM-Finite Element Method: Background, FEM from Weighted Residuals, Formulation (Basis Function, Mapping), Poisson Equation, Time Domain FEM (FETD)	7
5.	MOM- Method of Moments: Galerkin Method Integral Equation, Lorenz Gauge Integral Equation to Matrix Form, Wave equation using potentials, Green Function, Thin Wire Approximation, Magnetic Vector Potential, Incident and radiated field, Pulse basis function.	7

6.	FVM- Finite Volume Method: Motivation and Background Derivation of Eigen value Equation, Discretization Maxwell Equation, Flux function.	4
Total lectures		42

Suggested Text Book(s):

1. A. Bondeson, T. Rylander, and P. Ingelstom, “Computational Electromagnetics”, Springers, 2005
2. A. C. Ballanis, “Antenna theory analysis and design”, John Willey and Son's Inc., New York, 2005

Suggested Reference Book(s):

1. R. E. Colin. “Foundations for Microwave Engineering” McGraw Hill, 2nd Edition, 2001
2. E. C. Jordan and K. G. Balmain, “Electromagnetic Waves and Radiating Systems” Prentice Hall. Englewood Cliffs, New Jersey, 1998
3. S. Y. Liao, “ Microwave solid-state devices”, Prentice Hall, 1985
4. D. M. Pozar, “Microwave engineering”, John Wiley & Sons, 2009

Other useful resource(s):

1. NPTEL online course: https://nptel.ac.in/courses/108/101/108101090

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO1	2	1	3	3	3	2	1	1	1	1	1	1	1.67
CO2	3	3	3	2	2	2	1	1	3	3	2	3	2.33
CO3	3	3	3	3	2	2	1	1	3	2	2	3	2.33
CO4	3	3	3	3	2	2	1	1	3	2	2	2	2.25
Average	2.75	2.50	3.00	2.75	2.25	2.00	1.00	1.00	2.50	2.00	1.75	2.25	

Microwave Theory and Techniques

COURSE CODE: 18B1WEC731

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basics of Electromagnetic

Engineering Course Objectives:

2. To learn the basic principles of microwave generators and amplifiers.
3. To have foundations on microwave design principles and measurement.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To identify different microwave components and their applications.	Familiarity
CO-2	To study the performance of specialized microwave tubes such as klystrons.	Familiarity
CO-3	To understand the principle of operation of magnetrons, traveling wave tubes and BWOs.	Assessment
CO-4	To understand the working principle of microwave solid state devices and their applications.	Assessment
CO-5	To design of microwave filters, amplifiers and oscillators.	Usage
CO-6	To learn about microwave power, VSWR, impedance and attenuation measurements.	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Introduction to microwaves, Scattering matrix of microwave waveguide junction, properties of S-matrix, E-plane tee, H-plane tee, magic tee, attenuators, directional couplers, ferrite devices, Faraday rotation, gyrator, isolator, circulators and cavity resonators.	8
2	Microwave Tubes: Limitations and losses of conventional tubes at microwave frequencies, microwave tubes-O-type and M-type classifications. O-type tubes: Two cavity klystron-structure, reentrant cavities, velocity modulation process and apple gate diagram, bunching process and small signal theory- expression for output power and efficiency. Reflex Klystron-Structure, velocity modulation and apple gate diagram, mathematical theory of bunching, power output, efficiency, oscillating modes and output characteristics.	9

3	Microwave Crossed-Filed Tubes: M-Type tubes: Introduction, cross filed effects, magnetrons-different types, cylindrical travelling wave magnetron-Hull cut-off and Hartree conditions, mode of resonance and PI-mode of operations, separation of PI-mode, output characteristics, Backward wave crossed field oscillator (Carcinotron).	6
4	Helix TWTs: Significance, types and characteristics of slow wave structures, structure of TWT and amplification process (qualitative treatment), suppression of oscillations, gain considerations.	5
5	Microwave Solid state Devices: Introduction, classification, applications. TEDs-Introduction, Gunn diodes-principle, RWH theory, characteristics, modes of operations, IMPATT diode, TRAPATT Diode, BARITT diode, PIN diode, Tunnel diode.	7
6	Microwave Design Principles and Measurements: Microwave Filter Design, Microwave Amplifier Design, Low Noise Amplifier Design, Microwave Oscillator Design, VSWR and impedance measurement, attenuation measurement and power measurement.	7
Total lectures		42

Suggested Text Book(s):

1. Samuel Y.Liao, " Microwave Devices and Circuits", 3rd Edition, Pearson education, 2003.
2. R.E.Collin, "Foundations for microwave Engineering", 2nd Edition, Tata Mc Graw Hill, 1992.
3. Pozar, David M. "Microwave engineering", 4th Edition, John Wiley & Sons, 2013.

Suggested Reference Book(s):

1. Annapurna Das, Sisir.K.Das, "Microwave Engineering",1st Edition, Tata McGraw Hill, 2000.

Other useful resource(s):

1. Link to topics related to course: https://nptel.ac.in/courses/108101112

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Microwave Theory and Techniques)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	1	2	1	1	2	1	2	2	2	2	1	1.58
CO-2	2	3	3	3	3	1	2	1	1	2	1	1	1.92
CO-3	3	2	2	2	3	1	1	1	2	2	2	1	1.83
CO-4	2	3	3	3	2	1	2	1	1	3	1	2	2.0
CO-5	3	3	3	3	2	1	1	1	2	3	2	1	2.08
CO-6	3	3	2	2	3	1	1	1	1	2	1	2	1.83
Average	2.5	2.5	2.5	2.33	2.33	1.16	1.33	1.16	1.5	2.33	1.5	1.33	

Antenna and Wave Propagation

COURSE CODE: 18B1WEC735

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To make students understand the fundamental theory and concepts of antenna and propagation of waves.
2. Make them aware to the radiation characteristics of different types of antennas, their measurement and applicationsof various antennas.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Comprehend the fundamental theory and concepts of radiation, antenna and significance of antenna parameters.	Familiarity
CO-2	Assess the power and usefulness of UHF, VHF and Microwave Antennas, microstrip patch antennas their requirements, specifications, characteristics and design relations.	Assessment
CO-3	To define and distinguish between different phenomenon of wave propagation (ground wave, space wave and sky wave), their frequency dependence, and estimate their characteristics, identifying their profiles and parameters involved.	Assessment
CO-4	Reveal different applications of the various types of antenna to solve engineering and other problems	Usage

Course Contents:

Unit	Contents	Lectures required
1	ANTENNA FUNDAMENTALS: Introduction, Radiation Mechanism – single wire, 2 wire, dipoles, Current Distribution on a thin wire antenna. Antenna Parameters - Radiation Patterns, Beamwidths, Beam Area, Radiation Intensity, Beam Efficiency, Directivity, Gain and Resolution, Antenna Apertures, Aperture Efficiency Antenna temperature and signal to noise ratio.	7
2	RADIATION OF ELECTRIC DIPOLE: Potential functions and the electromagnetic field, Oscillating electric dipole derivations for E and H field components in spherical coordinate systems, Power Radiated by a current element, Application to antennas, Radiation from quarter wave monopole and half wave dipoles, equality of directional patterns and effective lengths of transmitting and receiving antennas, directional properties of dipole antennas, antenna feeding methods.	8

3	ANTENNAS FOR SPECIAL APPLICATIONS: Broadband antenna, Frequency-independent antenna, log periodic antennas, Antennas design consideration for satellite communication, antenna for terrestrial mobile communication systems, GPR, Embedded antennas, UWB, Plasma	6
4	ANTENNA MEASUREMENTS: Radiation Pattern measurement, Distance requirement for uniform phase, uniform field amplitude requirement, Introduction to phase measurement; Gain Measurement: Comparison method, Near field method, Introduction to current distribution measurement, Measurement of antenna efficiency, measurement of Noise figure and noise temperature of an antenna polarization measurement, Anechoic Chamber measurement.	7
5	WAVE PROPAGATION - I: Concepts of Propagation – frequency ranges and types of propagations. Ground Wave Propagation–Characteristics, Parameters, Wave Tilt, Flat and Spherical Earth Considerations. Sky Wave Propagation – Formation of Ionospheric Layers and their Characteristics, Mechanism of Reflection and Refraction, Critical Frequency, MUF & Skip Distance – Calculations for flat and spherical earth cases, Optimum Frequency, LUHF, Virtual Height, Ionospheric Abnormalities, Ionospheric Absorption.	7
6	WAVE PROPAGATION – II: Fundamental Equation for Free-Space Propagation, Basic Transmission Loss Calculations. Space Wave Propagation – Mechanism, LOS and Radio Horizon. Tropospheric Wave Propagation – Radius of Curvature of path, Effective Earth's Radius, Effect of Earth's Curvature, Field Strength Calculations, M-curves and Duct Propagation, Tropospheric Scattering.	7
Total lectures		42

Suggested Text Book(s):

1. E.C.Jordan and Balmain: Electromagnetic waves and Radiating Systems, 2nd Edition, PHI, 2006
2. Constantine A. Balanis: Antenna Theory Analysis and Desin, John Wiley, 2nd Edition,2007.

Suggested Reference Book(s):

1. John D.Kraus, Ronald J Marhefka and Ahmad S Khan: Antennas for all Applications, Tata McGraw-Hill Book Company, 3rd Edition, 2007.
2. G.S.N.Raju: Antenna Wave Propagation, Pearson Education, 1st Edition, 2004.
3. R.E.Collins, "Antenna and Radiowave propagation", 3rd Edition, Mc Graw Hill, 2005.

Other resources/ learning website:

www.nptel.ac.in

www.antenna-theory.com

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2

3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Antenna and Wave Propagation)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	2	3	2	1	1	1	2	3	3	2.17
CO-2	3	3	3	3	3	2	1	1	1	2	2	3	2.25
CO-3	3	3	3	3	3	2	1	1	1	2	2	3	2.25
CO-4	3	3	3	3	3	3	3	2	3	3	3	3	2.92
Average	3	3	2.75	2.75	3	2.25	1.5	1.25	1.5	2.25	2.5	3	2.40

Design of Modern Antennas

COURSE CODE: 18B1WEC831

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Transmission lines and

E.M waves. Course Objectives:

1. To learn the mechanism of antenna, antenna performance parameters.
2. Design and analysis of various antennas for different applications.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To define overall needs and constraints of RF systems and antennas.	Familiarity
CO-2	To understand the mechanism of antenna radiation.	Familiarity
CO-3	To design and analyze various antennas for specific application.	Usage
CO-4	Size reduction techniques, Broad banding and multi band operation techniques in antenna design.	Usage
CO-5	Evaluate the opportunities involving technology, a product or a service required for developing a startup idea.	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	Introduction: antenna types, radiation mechanism, use of potential functions, radiated field, far field, antenna parameters, radiation pattern, directivity, numerical evaluation of directivity, gain, efficiency, impedance, loss resistance, polarization, linear polarization, circular and elliptic polarization, equivalent area, Friss equation.	6
2.	Dipole Antennas: Potential functions for analysis of radiated fields, Duality theorem, Reciprocity theorem for antennas, Radiation from current element, infinitesimal dipole, finite length dipole, half wave dipole	6
3.	Antenna Arrays: Analysis and Synthesis Review of antenna array basics, Linear arrays, circular array, planar (2D) arrays, sum and difference patterns, Effect of mutual couplings, Phased array antennas, scan Principles, Non uniform arrays, Dolph Chebyshev Arrays Binomial Arrays.	6
4	Broadband and Frequency Independent Antennas Helical antenna: Normal mode and axial mode helix Spiral antennas, Log Periodic antennas.	5

5.	Aperture Antennas Radiation from an aperture in an infinite ground plane, Radiation from rectangular and circular apertures, Radiation from a slotted rectangular waveguide Horn antenna: E plane and H plane sectoral horns, Pyramidal horn, Conical horn Reflector antennas parabolic reflector, methods of analysis, dual reflector antennas, offset reflector antenna, gain and efficiency calculations, scanning properties and cross polarization Lens antennas and their applications	7
6	Microstrip Antennas Rectangular patch antenna: cavity and transmission line models, Circular patch antenna Coupling mechanisms, circular polarization, Microstrip arrays, Broadband and Multi band microstrip antennas, Compact Microstrip Antennas.	7
7	Dielectric Resonator Antennas Introduction, radiation mechanism, advantages of DRA, types of DRA, feeding techniques, design method, modes.	5
Total lectures		42

Suggested Text Book(s):

1. Constantine A. Balanis: Antenna Theory Analysis and Desin, John Wiley, 3rd Edition, 2009.
2. Antennas for All Applications, J. D. Kraus and R. J. Marhefka, McGraw-Hill, Inc, 3rd Ed., 2007.
3. Rectangular Dielectric Resonator Antennas, Rajveer S. Yaduvanshi Harish Parthasarathy, Springer, 1st Ed, 2016.

Suggested Reference Book(s):

1. Antennas and Radio wave Propagation, R. E. Collin, McGraw-Hill, Inc, 3rd Ed, 2005.
2. Modern Antenna Design, T. A. Milligan, John Wiley & Sons, 2nd Ed., 2005.
3. Antenna Arrays, R. L. Haupt, John Wiley & Sons, Inc., 1st Ed., 2010.
4. Antenna Theory and Microstrip Antennas, D. G. Fang, CRC Press, 1st Ed., 2009.

Other useful resource(s):

Link to NPTEL course contents

1. https://nptel.ac.in/courses/108101092/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Design of Modern Antennas)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	2	1	1	1	2	2	2	2.2
CO-2	2	3	3	3	2	2	1	1	2	1	1	2	1.9
CO-3	2	2	2	3	2	2	1	1	1	2	1	3	1.8
CO-4	2	2	3	3	2	1	1	2	2	2	2	2	2
CO-5	2	2	3	3	3	2	1	1	2	2	1	2	2
Average	2.2	2.4	2.8	3	2.4	1.8	1	1.2	1.6	1.6	1.4	2.2	

RF Engineering

COURSE CODE: 18B1WEC835

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic knowledge of Electromagnetic Engineering

Course Objectives:

1. To lay strong foundations in RF and microwave engineering.
2. To apply the theoretical knowledge acquired in the design of different components in microwave systems.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To have a thorough knowledge of RF and microwave components	Familiarity
CO-2	To have a thorough knowledge about different parameters involved in microwave receiver and their significance	Assessment
CO-3	To have a thorough knowledge about different parameters involved in microwave receiver and their significance	Assessment
CO-4	To design different RF filters according to certain specifications	Usage
CO-5	To understand active microwave components and their use in different applications	Usage

Course Contents:

Unit	Contents	Lectures required
1	Review of Waves and Transmission Lines: Wave Propagation, Transmission Line Equations, Reflection, Transmission, and impedance for a Terminated Transmission Line, Voltage Standing-Wave Ratio, Decibels, insertion Loss, Return Loss, Smith Charts, S-Parameters, Impedance Matching Networks.	5
2	Receiver System Parameters: Typical Receivers, System Considerations, Natural Sources of Receiver Noise, receiver Noise Figure and Equivalent Noise Temperature, Compression Points, Minimum detectable Signal and Dynamic Range, Third-Order Intercept Point and Intermodulation, spurious Responses, Spurious-Free Dynamic Range	8
3	Transmitter and Oscillator Systems: Transmitter Parameters, Transmitter Noise, Frequency Stability and Spurious Signals, Frequency Tuning, Output Power, and Efficiency, Intermodulation, Crystal Reference Oscillators, Phase-Locked Oscillators, frequency Synthesizers	6
4	Design of RF filters: Periodic Structures, Filter Design by the Image Parameter Method, Filter Design by the Insertion Loss Method, Characterization by Power Loss Ratio Filter transformations, Filter Implementation, Stepped-Impedance Low-Pass	9

5	Fabrication Technologies: Lumped Elements for RF circuits: Basic Design of Lumped elements, Lumped element modeling, printed inductors, MIM capacitor and Interdigital capacitor, Monolithic Integrated circuit technology (MIC), Monolithic microwave integrated circuit (MMIC) technology, material, RF printed circuit boards.	9
6	Wireless Communication Systems: Friis Transmission Equation, Space Loss, Link Equation and Link budget, Effective Isotropic Radiated Power and G/T Parameters, Radio/Microwave Links, Satellite Communication Systems, Mobile Communication Systems and Wireless cellular phones, Personal Communication Systems	5
Total lectures		42

Suggested Text Book(s):

1. Kai Chang, "RF and Microwave Wireless Systems",1st Edition, John Wiley & Sons, 2002.
2. Pozar, David M. "Microwave engineering", 4th Edition, John Wiley & Sons, 2013.
3. Bahl I.J "Lumped Elements for RF and Microwave Circuits"1st Edition, Artech House,2003.

Suggested Reference Book(s):

4. R.E.Collin, "Foundations for microwave Engineering", 2nd Edition, John Wiley & Sons, 2007.
5. Annapurna Das, Sisir.K.Das, "Microwave Engineering",1st Edition, Tata McGraw Hill, 2000.

Other useful resource(s):

Link to NPTEL course contents:

https://nptel.ac.in/courses/117101119/

https://nptel.ac.in/courses/117105138/

Link to topics related to course:

https://nptel.ac.in/courses/117105138/ 1 to 18

https://nptel.ac.in/courses/117101119/ 1 to 14

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (RF Engineering)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	1	1	1	2	1	2	1.7
CO-2	2	3	2	3	2	2	1	1	1	2	1	2	1.8
CO-3	3	3	3	3	3	2	1	1	1	2	1	2	2.1
CO-4	2	2	2	2	2	2	1	1	1	3	1	2	1.8
CO-5	3	2	3	2	2	2	1	1	1	2	1	2	1.8
Average	2.4	2.4	2.4	2.4	2.2	2.0	1.0	1.0	1.0	2.2	1.0	2.0	