Semester VII

Theory/ Practical	Sl. No	Course Type	Course Code	Course Name	Hours per week			Credit
					L	T	P	C
T/P	1.	PCC	BEC23501	Optical fibre Communication	2	1	2	4
T/P	2.	PCC	BEC23502	Mixed Signal Design	3	0	2	4
T/P	3.	PE-2	BEC2352X	Program Electve -2	2	1	0	3
T/P	4.	PE-3	BEC2352X	Program Elective - 3	2	1	0	3
T	5.	OE-3	BEC2353X	Open Elective - 3	3	0	0	3
T	6.	HSM-4	BEC23503	Project-1	0	0	8	4
P	7.	PCC	BEC23504	Internship	0	0	0	2
				Total	**15**	**3**	**6**	**23**

Program Elective	Course Code	Course Name
2	BEC23520	Biomedical Electronics
2	BEC23521	Sensor and Actuator
3	BEC23522	Computer Networking
4	BEC23523	Operating System
3	BEC23524	AI & Machine Learning
3	BEC23525	Introduction to MEMS

MOEC	Course Code	Course Name
3	BEC23530	Computer Architecture
3	BEC23531	Nanoelectronics
3	BEC23532	Cyber Security
3	BEC23533	Quantum Electronics

BEC23501	Optical fibre Communication	2L:1T:0P	3 Credits

Pre-requisites: EMF Theory

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1: Understand different models of light and their limitations.
CO2: Understand propagation of light in different types of optical fibers and signal degradation.
CO3: Design analog and digital optical communication links and analyze their performance.
CO4: Understand, analyze and design high-capacity advanced optical communication systems

Course Contents:

MODULE	*CONTENT*	*No. of CLASSES*
MODULE 1	Introduction to vector nature of light, propagation of light, propagation of light in a cylindrical dielectric rod, Ray model, wave model.	***5***
MODULE 2	Different types of optical fibers, Modal analysis of a step index fiber. Signal degradation on optical fiber due to dispersion and attenuation. Fabrication of fibers and measurement techniques like OTDR.	*7*
MODULE 3	Optical sources - LEDs and Lasers, Photo-detectors - pin-detectors, detector responsivity, noise, optical receivers. Optical link design - BER calculation, quantum limit, power penalties.	***8***
MODULE 4	Optical switches - coupled mode analysis of directional couplers, electro-optic switches. Nonlinear effects in fiber optic links. Concept of self-phase modulation, group velocity dispersion and soliton-based communication. Optical amplifiers - EDFA, Raman amplifier, Coherent communication and WDM systems.	***8***

Text/Reference Books:

1. J. Keiser, Fibre Optic communication, McGraw-Hill, 2nd Ed. 1992.
2. John M Senior," Optical Fiber Communications Principles and Practice", Pearson 3rd Edition
3. J.E. Midwinter, Optical fibers for transmission, John Wiley, 1979.
4. T. Tamir, Integrated optics, (Topics in Applied Physics Vol.7), Springer-Verlag, 1975.
5. J. Gowar, Optical communication systems, Prentice Hall India, 1987.
6. G. Agrawal, Fiber optic Communication Systems, John Wiley and sons, New York, 1992

BEC23501P	Optical fibre Communication Lab

Course outcomes:

At the end of this course students will demonstrate the ability to

CO1: Measure and analyze the numerical aperture and attenuation characteristics of optical fibers at different wavelengths, including bending and coupling losses.
CO2: Evaluate the performance of optical communication components such as LASER Diodes and Avalanche Photodiodes through V-I and P-I characteristic analysis.
CO3: Investigate the effect of electromagnetic/radio frequency interference on optical fiber communication systems and interpret the observed behavior.

CO4: Perform experimental characterization of optical fiber links and optoelectronic devices usingstandard optical communication laboratory instruments and interpret the obtained results effectively.

List of Lab Experiment:

1. To Measure the Numerical Aperture of a given Optical Fiber.
2. To Measure the Losses of a given Optical Fiber:
   a. Attenuation at 650nm
   b. Attenuation at 850nm
   c. Bending Loss
   d. Coupling Loss
3. To observe the Electromagnetic/Radio Frequency Interference in a given Optical Fiber.
4. Plot the Power Vs Current (P-I) graph and Voltage Vs Current (V-I) graph for an LD (LASER Diode) unit. (Using Power meter and different wavelengths of LD module unit)
5. Plot the Power Vs Current graph for an Avalanche Photo Diode (APD) at zero bias.
6. To connect the Avalanche Photo Diode in Reverse bias and plot the graph between Voltage(Bias) Vs Load Current

Text/Reference Books:

1. Optical Fiber Communications by Gerd Keiser
2. Fiber-Optic Communication Systems by Govind P. Agrawal
3. Optical Communications: Principles and Practice by John M. Senior
4. Fiber Optic Communications by Joseph C. Palais

BEC23502	**Mixed Signal Design**	**3L:0T:2P**	**4 Credits**

Pre-requisites: Students should have prior knowledge of: Analog Electronic Circuits, Digital Electronics and Logic Design, CMOS/VLSI Fundamentals, Signals and Systems, Basic Network Theory, Semiconductor Devices and Electronic Devices, Basic Communication Systems concepts, Laplace Transform and Z-Transform fundamentals

Course Outcomes:

At the end of this course students will demonstrate the ability to
CO1: ***Understand the concepts and fundamentals of mixed-signal circuits.***
CO2*: Analyze the characteristics and performance of IC-based CMOS filters.*
CO3: ***Design and evaluate various data converter architecture circuits.***
CO4: ***Analyze signal-to-noise ratio and modeling aspects of mixed-signal systems.***

Course Contents:

MODULE	*CONTENT*	*No. of CLASSES*
MODULE 1	**Introduction to Mixed-Signal Processing and Filters:** Analog and discrete-time signal processing; introduction to sampling theory; analog continuous-time filters; passive and active filters; basics of analog discrete-time filters; Z-transform.	*8*
MODULE 2	**Switched-Capacitor Filters:** Introduction to switched-capacitor filters; switched-capacitor filter architectures; switched-capacitor filter applications; nonidealities in switched-capacitor filters, including charge injection and clock feedthrough.	*8*
MODULE 3	**Comparators, Reference Circuits and Data Converter**	*10*

	Architectures: Introduction to static and dynamic comparators; comparator performance parameters; reference voltage generators and Bandgap Reference (BGR) circuits; basics of data converters; successive approximation ADCs; dual-slope ADCs; flash ADCs; pipeline ADCs; hybrid ADC structures; high-resolution ADCs; DACs.	
MODULE 4	**Mixed-Signal Interconnects and Data Transmission**: Mixed-signal layout, interconnects, and data transmission, voltage-mode signaling and data transmission, current-mode signaling and data transmission.	*7*
MODULE 5	**Frequency Synthesizers and Synchronization Circuits:** Introduction to frequency synthesizers and synchronization, basics of PLL, analog PLLs, digital PLLs, and DLLs.	*7*

Text / Reference Books

1. R. Jacob Baker, CMOS Mixed-Signal Circuit Design, Wiley-IEEE Press, Reprint 2008.
2. R. Jacob Baker, CMOS Circuit Design, Layout and Simulation, Wiley-IEEE Press, Second Edition, Reprint 2009.
3. Behzad Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill Education, Reprint 2016.

Suggested Additional References

1. Behzad Razavi, Principles of Data Conversion System Design, IEEE Press.
2. R. Gregorian and G. C. Temes, Analog MOS Integrated Circuits for Signal Processing, Wiley.

BEC23502P	**Mixed Signal Design Lab**

Course Objectives

CO1. Understand the CMOS VLSI design flow, fabrication process, MOS transistor operation, and layout methodologies.

CO2. Design, simulate, and verify CMOS combinational and sequential logic circuits using EDA tools.

CO3. Analyze circuit performance with respect to propagation delay, power dissipation, transistor sizing, and interconnect effects.

CO4. Design and evaluate CMOS analog building blocks and digital subsystems including amplifiers,
adders, multiplexers, flip-flops, and memory cells.

CO5. Develop complete transistor-level layouts, perform DRC/LVS verification, interpret simulation results, and document experimental findings using standard engineering practices.

List of Experiment

1 Design, Simulation and Analysis of CMOS Inverter. DC Transfer Characteristics, Noise Margin and Switching Characteristics of CMOS Inverter
2 Design, Simulation and Analysis of NAND/NOR/XOR/XNOR GATE 3 Design and Verification of Half Adder and Full Adder Using CMOS Logic. Design and Analysis of 2:4 Decoder and 4:1 Multiplexer Using CMOS Logic

4 Analysis of Propagation Delay, Rise Time, Fall Time and RC Delay in CMOS Circuits.

5 Measurement and Analysis of Static and Dynamic Power Dissipation in CMOS Circuits

6 Effect of Transistor Sizing on Delay, Power and Switching Performance.

7 Design and Simulation of CMOS Latches and Flip-Flops (SR, D and Master-Slave D Flip-Flop)

8 Design and Analysis of Common Source, Common Drain and Differential Amplifiers

9 Design and Simulation of Two-Stage CMOS Operational Amplifier

10 Design and Verification of Comparator, Ripple Carry Adder and 4-bit Counter

11. Design, Simulate and analyse 6T SRAM Cell with Read and Write Operations.

12. Layout design of a CMOS inverters and its analysis.

BEC23520	Biomedical Electronics	3L:0T:0P	3 Credits

Pre-requisites: Basic Electronics, Electronic Devices and Circuits , Analog Electronic Circuits, Signals and Systems, Network Theory, Basic Electrical and Electronic Measurements

Course Outcomes (COs)

After successful completion of the course, students will be able to

CO1. Explain the anatomy and physiology of major human organ systems and the origin of biomedical signals.

CO2. Analyse biomedical sensors, electrodes and physiological transducers used in medical diagnosis.

CO3. Design basic biomedical signal acquisition and conditioning circuits for physiological measurements.

CO4. Explain the working principles of medical imaging systems and therapeutic biomedical equipment.

CO5. Describe modern biomedical electronic systems including patient monitoring, wearable healthcare devices and telemedicine.

Course Contents:

MODULE	*CONTENT*	*No. of CLASSES*
MODULE 1	**Introduction to Human Physiology and Bioelectric Signals:** Cell structure and membrane potential; physiology of nerve and muscle; cardiovascular system; respiratory system; nervous system; auditory system; origin of bioelectric signals; characteristics of biomedical signals; Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG) and Phonocardiogram (PCG).	*8*
MODULE 2	**Biomedical Electrodes and Transducers:** Characteristics of biomedical transducers; Ag/AgCl electrodes; ECG, EEG and EMG electrodes; microelectrodes; resistive, inductive and capacitive transducers; Linear Variable Differential Transformer (LVDT); piezoelectric transducers; temperature measurement; photoelectric transducers; blood pressure transducers; pH measurement sensors.	*8*
MODULE 3	**Biomedical Signal Conditioning and Recording Systems:** Biomedical amplifiers; differential amplifier; instrumentation amplifier; isolation amplifier; current-to-voltage converter; biomedical filters (LPF, HPF, Band-pass and Notch filter); sources of noise in	*10*

	biomedical measurements; grounding and shielding; recording systems for ECG, EEG, EMG and PCG; introduction to data acquisition systems.	
MODULE 4	**Diagnostic Biomedical Instruments:** Electrocardiograph (ECG); Electroencephalograph (EEG); Electromyograph (EMG); Phonocardiograph (PCG); electronic blood pressure measurement; pulse oximeter; spirometer; electronic thermometer; glucometer; patient monitoring systems.	***7***
MODULE 5	**Medical Imaging and Therapeutic Equipment:** X-ray imaging; Computed Tomography (CT); Ultrasonography; Magnetic Resonance Imaging (MRI); thermal imaging; cardiac pacemaker; cardiac defibrillator; haemodialysis machine; lithotripter; ventilator; hearing aids and cochlear implant (brief introduction).	***7***

Text Book

1. **R. S. Khandpur**, *Handbook of Biomedical Instrumentation*, Tata McGraw-Hill Education, 3rd/4th Edition.

Reference Books

1. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, *Biomedical Instrumentation and Measurements*, Pearson Education.
2. John G. Webster, *Medical Instrumentation: Application and Design*, Wiley.
3. John Enderle, Susan Blanchard and Joseph Bronzino, *Introduction to Biomedical Engineering*, Academic Press.

BEC23521	**Sensor and Actuator**	**3L:0T:0P**	**3 Credits**

Prerequisite: Knowledge of Electronic Devices and Circuits, Analog Electronics, Sensors and Instrumentation, Microcontrollers, and Basic Control Systems.

Course Outcomes

At the end of the course, students will be able to

CO1: Explain the operating principles, characteristics and performance parameters of various sensors.

CO2: Select suitable sensors for measuring physical, thermal, optical and chemical parameters.

CO3: Analyse signal conditioning and interfacing techniques used with sensors.

CO4: Explain the operating principles and applications of electrical, pneumatic and hydraulic actuators.

CO5: Design basic sensing and actuation systems for industrial automation and embedded applications.

Course Contents

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	**Introduction to Sensors and Smart Sensing Systems:** Introduction to sensors and transducers; classification of sensors; sensor specifications and selection criteria; static and dynamic characteristics; sensor modelling; calibration techniques; smart sensors; digital sensors; intelligent sensing systems; overview of sensor applications in industrial automation, robotics, automotive, biomedical and IoT systems.	***8***

MODULE 2	**Mechanical and Industrial Sensors:** Resistive sensors; strain gauges; piezoresistive sensors; capacitive sensors; inductive sensors; Linear Variable Differential Transformer (LVDT); eddy current sensors; piezoelectric sensors; displacement, position, velocity, acceleration, force, pressure, vibration, torque, flow and level sensors; industrial applications and sensor selection.	***8***
MODULE 3	**Thermal, Optical, Magnetic, MEMS and Chemical Sensors:** Temperature sensors (RTD, thermistor, thermocouple, semiconductor temperature sensors); humidity sensors; optical sensors; photodiodes; phototransistors; fibre optic sensors; Hall-effect sensors; magnetoresistive sensors; ultrasonic sensors; proximity sensors; gas sensors; chemical sensors; MEMS sensors; MEMS accelerometers; MEMS gyroscopes; biosensors; smart sensor technologies.	***10***
MODULE 4	**Sensor Signal Conditioning and Embedded Interfacing:** Signal conditioning; bridge circuits; instrumentation amplifiers; isolation amplifiers; filtering; analogue-to-digital and digital-to-analogue conversion; sensor calibration; noise reduction and shielding; data acquisition systems; interfacing sensors with microcontrollers; digital communication interfaces (I^2C, SPI, UART and CAN); wireless sensor networks; IoT-based sensing systems.	***7***
MODULE 5	**Actuators and Smart Actuation Systems:** Classification of actuators; electromagnetic actuators; DC motors; stepper motors; servo motors; BLDC motors; solenoids; relays; voice coil actuators; piezoelectric actuators; shape memory alloy actuators; pneumatic actuators; hydraulic actuators; electro-pneumatic systems; valve actuators; actuator selection; applications in industrial automation, robotics, automotive systems, biomedical devices and smart manufacturing.	***7***

Text Book

1. **Jacob Fraden**, *Handbook of Modern Sensors: Physics, Designs, and Applications*, **5th Edition**, Springer, 2016.

Reference Books

1. **D. Patranabis**, *Sensors and Transducers*, **2nd Edition**, PHI Learning Pvt. Ltd., New Delhi, 2013.
2. **Ramon Pallás-Areny** and **John G. Webster**, *Sensors and Signal Conditioning*, **2nd Edition**, John Wiley & Sons, 2001.
3. **Ernest O. Doebelin** and **Dhanesh N. Manik**, *Measurement Systems: Application and Design*, **6th Edition**, McGraw-Hill Education, 2011.
4. **John P. Bentley**, *Principles of Measurement Systems*, **4th Edition**, Pearson Education, 2005.
5. **W. Bolton**, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, **7th Edition**, Pearson Education, 2021.
6. **John G. Webster** and **Halit Eren (Editors)**, *Measurement, Instrumentation, and Sensors Handbook*, **2nd Edition**, CRC Press, 2014.
7. **S. R. Vadera**, *Sensors and Actuators*, Khanna Publishers, New Delhi, 2016.

BEC23522	**Computer Networking**	**3L:0T:0P**	**3 Credits**

Prerequisite: Knowledge of Digital Electronics, Data Communication, Microprocessors and Microcontrollers, Communication Systems, and basic programming concepts.

Course Outcomes

At the end of this course, students will be able to:

CO1: Explain the architecture, layered models and protocols used in computer networks.
CO2: Analyse data communication techniques, routing algorithms and transport protocols.
CO3: Evaluate Local Area Networks (LANs), wireless networks and Internet protocols.
CO4: Explain network security mechanisms and network management techniques.
CO5: Analyse modern networking technologies including IoT, Software Defined Networking (SDN) and cloud networking.

Course Contents

MODULE	*CONTENT*	*No. of CLASSES*
MODULE 1	**Introduction to Computer Networks:** Network architecture; OSI reference model; TCP/IP model; network topologies; transmission media; switching techniques (Circuit, Message and Packet Switching); multiplexing; network devices (Hub, Bridge, Switch, Router, Gateway); performance parameters; IPv4 and IPv6 addressing; subnetting concepts.	*8*
MODULE 2	**Data Link and Network Layer:** Data link layer services; framing; error detection and correction (CRC, Hamming Code); flow control; ARQ protocols; Medium Access Control (ALOHA, CSMA/CD, CSMA/CA); Ethernet; VLAN; routing principles; shortest path routing; distance vector routing; link state routing; routing protocols (RIP, OSPF); Internet Protocol (IP); ICMP; ARP; DHCP.	*9*
MODULE 3	**Transport Layer and Application Layer:** Transport layer services; UDP; TCP; flow control; congestion control; Quality of Service (QoS); socket programming concepts; DNS; HTTP/HTTPS; FTP; SMTP; POP3; IMAP; Telnet; SSH; SNMP; multimedia communication; Voice over IP (VoIP).	*8*
MODULE 4	**Wireless and Mobile Networks:** IEEE 802.11 WLAN; Bluetooth; ZigBee; RFID; Cellular communication (4G and 5G overview); Mobile IP; Wireless Sensor Networks (WSN); Internet of Things (IoT) architecture; LPWAN technologies (LoRa and NB-IoT); edge computing; applications in smart cities and industrial automation.	*8*
MODULE 5	**Network Security and Emerging Trends:** Cryptography fundamentals; authentication; firewalls; VPN; intrusion detection systems; network attacks; secure communication protocols (SSL/TLS); Software Defined Networking (SDN); Network Function Virtualization (NFV); cloud networking; network management; future Internet technologies.	*7*

Text Book

1. **Behrouz A. Forouzan**, *Data Communications and Networking*, 5th Edition, McGraw-Hill Education, 2013.

Reference Books

1. **Andrew S. Tanenbaum** and **David J. Wetherall**, *Computer Networks*, 5th Edition, Pearson Education, 2011.
2. **James F. Kurose** and **Keith W. Ross**, *Computer Networking: A Top-Down Approach*, 8th Edition, Pearson Education, 2022.
3. **Larry L. Peterson** and **Bruce S. Davie**, *Computer Networks: A Systems Approach*, 6th Edition, Morgan Kaufmann, 2021.
4. **William Stallings**, *Data and Computer Communications*, 11th Edition, Pearson Education, 2017.

BEC23523	Operating System	3L:0T:0P	3 Credits

Prerequisite: Knowledge of Computer Organization and Architecture, Microprocessors and Microcontrollers, Digital Electronics, Data Structures, and basic programming concepts.

Course Outcomes

At the end of this course, students will be able to:

CO1: Explain the architecture, services and functions of modern operating systems.

CO2: Analyse process scheduling, synchronization and deadlock handling techniques.

CO3: Explain memory management, virtual memory and file system organization.

CO4: Analyse embedded and real-time operating systems used in communication and embedded applications.

CO5: Explain modern operating system technologies including multicore processing, virtualization and cloud computing

Course Contents:

MODULE	*CONTENT*	*No. of CLASSES*
MODULE 1	**Introduction to Operating Systems:** Operating system concepts; functions and services; operating system architecture; system calls; kernel and user mode; monolithic, layered, microkernel and hybrid operating systems; process concept; process states; process control block; threads and multithreading; inter-process communication.	*8*
MODULE 2	**Process Management and CPU Scheduling:** CPU scheduling criteria; scheduling algorithms (FCFS, SJF, Priority, Round Robin, Multilevel Queue and Multilevel Feedback Queue); process synchronization; critical section problem; semaphores; mutex; monitors; classical synchronization problems; deadlocks; deadlock prevention, avoidance, detection and recovery.	*9*
MODULE 3	**Memory Management and File Systems:** Memory management techniques; contiguous and non-contiguous allocation; paging; segmentation; virtual memory; demand paging; page replacement algorithms (FIFO, LRU, Optimal); thrashing; file concepts; file allocation methods; directory structures; disk scheduling algorithms (FCFS, SSTF, SCAN, C-SCAN).	*9*
MODULE 4	**Embedded and Real-Time Operating Systems:** Characteristics of embedded operating systems; real-time operating systems (RTOS); hard and soft real-time systems; RTOS scheduling; interrupt handling; task management; memory management in embedded systems; overview of FreeRTOS, Embedded Linux and Android operating systems; applications in IoT and communication systems.	*7*
MODULE 5	**Modern Operating Systems:** Multicore operating systems; multiprocessing; virtualization; virtual machines; containers; cloud computing concepts; operating system security; authentication and access control; Linux shell basics; performance monitoring; future trends in operating systems.	*7*

Text Book

1. **Abraham Silberschatz, Peter B. Galvin and Greg Gagne**, *Operating System Concepts*, **10th Edition**, John Wiley & Sons, 2018.

Reference Books

1. **Andrew S. Tanenbaum** and **Herbert Bos**, *Modern Operating Systems*, **5th Edition**, Pearson, 2023.
2. **William Stallings**, *Operating Systems: Internals and Design Principles*, **9th Edition**, Pearson, 2018.
3. **D. M. Dhamdhere**, *Operating Systems: A Concept-Based Approach*, **3rd Edition**, McGraw Hill Education, 2017.
4. **Jane W. S. Liu**, *Real-Time Systems*, Pearson Education, 2000.
5. **Raj Kamal**, *Embedded Systems: Architecture, Programming and Design*, **3rd Edition**, McGraw Hill Education, 2017.

BEC23524	Artificial Intelligence & Machine Learning	2L:1T:0P	3 Credits

Pre-requisites: Engineering Mathematics, Probability and Statistics, Programming Fundamentals (Python/C) and Signals and Systems

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1: Understand the fundamental concepts of Artificial Intelligence, Machine learning and Deep Learning Techniques.

CO2: Apply supervised and unsupervised machine learning algorithms for data analysis, classification, clustering, and prediction problems.

CO3: Analyze and design neural network and deep learning models for engineering and real-world applications.

CO4: Implement AI and machine learning solutions using Python libraries and modern AI development tools.

Course Contents:

MODULE	CONTENT	No. of CLASSES
MODULE 1	**Mathematical Foundations for AI and ML**: Review of Probability theory- Conditional Probability, Bayes Theorem, Random Variables, Probability Distributions; Review of Linear Algebra, Vectors and Matrices, Eigenvalues and Eigenvectors, Matrix Operations, Convex Optimization, Relationship between Artificial Intelligence, Machine Learning, and Deep Learning, Basic Data Science workflow, AI/ML Applications in ECE, Cross validation, Hyper parameter tuning after training, validation and testing	10

MODULE 2	**Statistical Decision Theory and Supervised Learning :** Introduction to Statistical Decision Theory, Regression Techniques- Linear Regression, Multivariate Regression; Data Collection and Preparation, Data Cleaning and Handling Missing Values, Feature Selection and Feature Scaling; Training, Validation and Testing; Classification Techniques: Logistic Regression, K-Nearest Neighbour (KNN), Decision Tree, Naïve Bayes, Support Vector Machine (SVM); Model Evaluation Metrics: Accuracy, Precision, Recall, F1 Score, Confusion Matrix; Maximum Likelihood and Least Squared Error Hypotheses, Maximum Likelihood Hypotheses for Predicting Probabilities **Hands on learning using Python**	10
MODULE 3	**Unsupervised Learning and Optimization:** Clustering Techniques, K-Means Clustering, Hierarchical Clustering, Dimensionality Reduction, Principal Component Analysis (PCA), Association Rule Mining; Introduction to Optimization-Gradient Descent Algorithm, Bias-Variance Trade off, Overfitting and Underfitting, Regularization Techniques (L1/L2) **Hands on learning using Python**	10
MODULE 4	**Ensemble learning, Neural Networks and Deep learning:** Model Evaluation and Ensemble Methods- Bootstrapping, Class Evaluation Measures, ROC Curve; Ensemble Learning- Bagging, Random Forest, Boosting, AdaBoost, Gradient Boost, XGBoost; Introduction to Neural Networks, Perceptron, Multi-layer neural networks, Artificial Neural Networks, Backpropagation, Introduction to CNN, RNN; Ethics in AI **Hands on learning using Python**	8
MODULE 5	**Model Deployment and Industrial Applications:** Introduction to Machine Learning Model Deployment, deployment pipeline, Deployment using Flask and FastAPI, edge AI, real-time inference and monitoring, Model Optimization Techniques- Quantization, Pruning, Transfer Learning, Deployment using TensorFlow Lite and ONNX, Case Studies/Mini Project on End-to-end ML solution with Deployment	7

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Text/Reference Books:

1. Singh, P., Gandhi, T. K., & Raman, B. (2025). Artificial intelligence and machine learning (1st ed.). Khanna Book Publishing Company.
2. Chopra, R. (2023). Machine learning. Khanna Book Publishing Company.
3. Hastie, T., Tibshirani, R., & Friedman, J. (2009). The elements of statistical learning: Data mining, inference, and prediction (2nd ed.). Springer.
4. Alpaydin, E. (2005). Introduction to machine learning. PHI Learning.
5. Bishop, C. M. (1995). Neural networks for pattern recognition. Oxford University Press.
6. Mitchell, T. M. (1997). Machine learning. McGraw-Hill.
7. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning: With applications in R. Springer.

BEC23525	**Introduction to MEMS**	**2L:1T:0P**	**3 Credits**

Pre-requisites: Semiconductor Devices and Circuits, VLSI Design

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1. Demonstrate the multidisciplinary aspects of MEMS and NEMS and their applications
CO2. Analyse the methods of fabrication and modeling methods.
CO3 Analyse the underlying working principles of MEMS and NEMS devices
CO4. Design and model MEMS and NEMS devices for engineering application

Course Contents:

Module	CONTENT	No. of Classes
Module 1	Introduction and Historical Background of MEMS/NEMS, Scaling Effects, Micro/Nano Sensors, Actuators and Systems Overview, Case Studies and Applications **Introduction to MEMS Materials**: Silicon, Polymers, Metals, Ceramics; Mechanical, Electrical and Thermal Properties of MEMS Materials	**7**
Module 2	**Review of Basic MEMS Fabrication Modules:** Oxidation, Deposition Techniques, Lithography (LIGA), Etching Techniques	**7**
Module 3	**Micromachining:** Surface Micromachining, Sacrificial Layer Processes, Stiction; Bulk Micromachining, Isotropic and Anisotropic Etching, Wafer Bonding	**7**
Module 4	**Mechanics of Solids in MEMS/NEMS:** Stress, Strain, Hooke's Law, Poisson Effect, Linear Thermal Expansion, Bending; Energy Methods, Overview of Finite Element Method	**7**
Module 5	**MEMS Sensors and Transducers**: Pressure Sensors, Piezoresistive Sensors, Piezoelectric Sensors, Capacitive Sensors, Inductive Sensors, Inertial Sensors (Accelerometers and Gyroscopes), Sensor Performance Parameters, Applications of MEMS Sensors	**7**
Module 6	**Magnetic and RF MEMS:** Magnetic Sensors , Hall Effect Sensors, Magnetoresistive Sensors, RF MEMS Switches and Components , Applications of RF MEMS in Wireless Communication **Thermal and Flow Sensors:** Thermocouples , Thermal Sensors , Flow Sensors , Shape Memory Alloys (SMA) and Smart Materials, MEMS Actuators based on SMA **Advanced MEMS Devices and Modeling**: Introduction to MEMS Simulation Tools and Applications, Modeling of Coupled Electromechanical Systems,	**10**
	Total	**45**

Text/Reference Books:

1. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan K. N. Bhat, V. K. Aatre, Micro and Smart Systems, Wiley India, 2012.
2. S. E.Lyshevski, Nano-and Micro-Electromechanical systems: Fundamentals of Nano-and Microengineering (Vol. 8). CRC press, (2005).
3. S. D. Senturia, Microsystem Design, Kluwer Academic Publishers, 2001.
4. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997.
5. G. Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill, Boston, 1998.
6. M.H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes, Elsevier, New York, 2000.

BEC23530	Computer Architecture	2L:1T:0P	3 Credits

Pre-requisites: **Knowledge of** Digital Electronics, Computer Organization and Architecture, Microprocessors and Microcontrollers, Data Structures, and basic programming concepts.

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1: Analyze the computing systems and their development processes
CO2. Analyze the performance of computers and the role of software and hardware in it.
CO3: Interface memory and I/O devices to CPU to make a complete system.
CO4: Understand the architecture of modern CPUs and issues related to them such as Cache Memories, out of order instruction execution etc.

Course Contents:

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	Basic Structure of Computers, Functional units, software, performance issues software, machine instructions and programs, Types of instructions, Instruction sets: Instruction formats, Assembly language, Stacks, Queues, Subroutines.	*9*
MODULE 2	Processor organisation, Information representation, number formats. multiplication & division ALU design, Floating Point arithmetic, IEEE 754 floating point formats	***10***
MODULE 3	Control Design, Instruction sequencing, Interpretation, Hard wired control - Design methods, and CPU control unit. Microprogrammed Control - Basic concepts, minimizing microinstruction size, multiplier control unit. Microprogrammed computers - CPU control unit, Multicore and Many-core Architectures., GPU Architecture Basics.	***9***
MODULE 4	Memory organization, device characteristics, RAM, ROM, Memory management, Concept of Cache & associative memories, Virtual memory,	***8***
MODULE 5	System organization, Input - Output systems, Interrupt, DMA, Standard I/O interfaces Concept of parallel processing, Pipelining, Forms of parallel processing, interconnect network	***9***
	Total	***45***

Text/Reference Books

1. Computer Organization — V. Carl Hamacher, Fifth Edition.
2. Structured Computer Organization — Andrew S. Tanenbaum, PHI, Third Edition.
3. Computer Organization and Microprogramming — Y. Chu, Prentice Hall.
4. Computer System Architecture — M. Morris Mano.
5. Computer Organization and Programming — C. W. Gear, McGraw Hill.
6. Computer Architecture and Organization — John P. Hayes, PHI, Second Edition.
7. Computer Organization and Architecture — Ikvinderpal Singh, Khanna Book Publishing.

BEC23531	Nanoelectronics	2L:1T:0P	3 Credits

Pre-requisites: Solid State Devices, Introductory Quantum Mechanics, Basics of Electromagnetic Fields.

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1: Analyze the physical, geometric, and electrical scaling limitations of conventional Silicon CMOS technology.

CO2*:* Explain quantum confinement effects and calculate changes in the density of states as materials are scaled down.

CO3: Differentiate between **"Top-Down"** fabrication and **"Bottom-Up"** synthesis.

CO4: Explain the underlying operating principles, V-I characteristics, and architecture of emerging nanoelectronic devices.

Course Contents:

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	Foundations of Nanoelectronics: Review of Moore's Law, scaling theory , Short-Channel Effects (SCEs), Progress from micro-scale gates to sub-10nm nodes	*8*
MODULE 2	Quantum Mechanics Foundations: Schrödinger Wave Equation, De Broglie Wavelength, Quantum Confinement & Dimensionality, Density of States (DoS)	***10***
MODULE 3	Nanoscale Electron Transport: Diffusive vs. Ballistic Transport, Single-Electron Charging, Single-Electron Transistor (SET), Resonant Tunneling Phenomena, Resonant Tunneling Diode (RTD)	***10***
MODULE 4	Nanofabrication and Characterization Techniques: "Top-Down" vs. "Bottom-Up" fabrication methods, fabrication of nano-layers -Physical Vapor Deposition, Chemical Vapor Deposition, Epitaxy, Molecular Beam Epitaxy, Ion Implantation, laser ablation, sol gel, self-assembly. Principle of operation of STM, AFM, SEM, TEM.	***10***
MODULE 5	Nanoelectronic Devices: FinFETs (Fin Field-Effect Transistors), Tunnel FETs (TFETs), Carbon Nanotubes and 2D Material Electronics,Molecular Electronics	*7*

Text/Reference Books:

1. George W. Hanson, “Fundamentals of Nanoelectronics”, PHI

2. V. Mitin, V. Kochelap, and M. Stroscio “Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications”, Cambridge University Press, 2008

BEC23532	Cyber Security	2L:1T:0P	3 Credits

Pre-requisites: Basic knowledge of Computer Networks, Operating Systems, and Digital Communication.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

CO1: Understand the basic concept of cyber security and its importance.

CO2*:* Analyze and distinguish various security threats and attacks that are prevalent.

CO3: Find different ways for the safety of assets and systems by increasing the strength of security parameters.

CO4: Perform simple simulations of cyber security attacks and ways to mitigate those.

Course Contents:

MODULE	*CONTENT*	*No. of CLASSES*
MODULE 1	**Cyber Security Concepts:** Cyber Risks, Breaches, attacks, Exploits, Social Engineering, Foot Printing, Scanning, etc.	**06**
MODULE 2	**Cryptography and Cryptanalysis:** Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls-Types of Firewalls, User Management, VPN Security.	**08**
MODULE 3	Infrastructure and Network Security: Introduction to System Security, Server Security, and OS Security, Physical Security, Introduction to Networks, Network Packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Introduction to Intrusion Detection and Prevention Techniques, Host-based Intrusion Prevention Systems, Security Information Management.	**08**
MODULE 4	**Cyber Security Vulnerabilities & Safeguards:** Internet Security, Cloud Computing & Security, Social Network sites security, Cyber Security Vulnerabilities-Overview, Vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber Security Awareness.	**08**
MODULE 5	**Malware:** Explanation of Malware, Types of Malwares: Virus, Worms, Trojans, Rootkits, Robots, Adware's, Spywares, Ransom wares, Zombies, etc., OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/services, another configuration), Malware Analysis. Open Source/ Free/ Trial Tools: Antivirus Protection, Anti-Spywares, System tuning tools, Anti-phishing.	**08**
MODULE 6	**Security in Evolving Technology:** Biometrics, Mobile Computing and Hardening on Android and iOS, IoT Security, Web server configuration, and Security. Basic security for HTTP, Applications, and Services, Including	**07**

	Basic Security for web services such as SOAP and REST. Identity Management and Web Services, Authorization Patterns, Security Considerations, and Challenges.	

Text/Reference Books:

1. Jeeva Jose & Vijo Mathew, Introduction to Security of Cyber-Physical Systems, Khanna Book Publishing Company, 2023.

2. William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006.

3. V.K. Jain, "Cryptography and Network Security", Khanna Publishing House.

4. Gupta Sarika, "Information and Cyber Security", Khanna Publishing House, Delhi.

5. Atul Kahate, "Cryptography and Network Security", McGraw-Hill.

6. V.K. Pachghare, "Cryptography and Information Security", PHI Learning

BEC23533	**Quantum Electronics**	**2L:1T:0P**	**3 Credits**

Prerequisite:
Knowledge of Engineering Physics, Electronic Devices, Semiconductor Devices, Electromagnetic Theory, and Optical Communication/Fibre Optics.

Course Outcomes
At the end of this course, students will be able to:
CO1: Explain the fundamental principles of quantum mechanics governing electronic and photonic devices.
CO2: Analyse atomic transitions, stimulated emission and light–matter interaction.
CO3: Explain the construction, operation and characteristics of different laser systems.
CO4: Analyse semiconductor lasers, optical amplifiers and photodetectors used in optical communication systems.
CO5: Describe modern applications of quantum electronics in fibre optic communication, sensing, quantum communication and photonic integrated circuits.

Course Contents:

MODULE	***CONTENT***	***No. of CLASSES***
MODULE 1	**Fundamentals of Quantum Mechanics:** Blackbody radiation; Planck's quantum theory; photoelectric effect; Compton effect; wave-particle duality; de Broglie hypothesis; Heisenberg uncertainty principle; Schrödinger wave equation; wave function and probability density; quantum states; potential well; tunnelling effect; introduction to energy bands in solids.	8
MODULE 2	**Interaction of Radiation with Matter:** Atomic energy levels; spontaneous emission; stimulated emission; absorption; Einstein coefficients; population inversion; pumping mechanisms; optical resonators; cavity modes; quality factor; line broadening mechanisms; laser rate equations (basic concepts)..	8
MODULE 3	**Laser Systems:** Characteristics of laser radiation; threshold	10

	condition; Ruby laser; He–Ne laser; CO_2 laser; Nd:YAG laser; semiconductor lasers; distributed feedback (DFB) lasers; quantum well lasers; laser beam characteristics; laser safety; industrial, medical and communication applications.	
MODULE 4	**Optoelectronic Devices and Optical Amplifiers:** Semiconductor light sources; LEDs; laser diodes; photodiodes (PIN and APD); phototransistors; optical amplifiers; Erbium-Doped Fibre Amplifier (EDFA); optical modulators; electro-optic and acousto-optic modulators; optical switches; photonic integrated circuits (introduction)..	7
MODULE 5	**Modern Quantum Electronic Systems:** Fibre optic communication systems; laser sensors; LiDAR; fibre optic sensors; holography; quantum dots; quantum cascade lasers (introduction); quantum communication; quantum cryptography (basic concepts); integrated photonics; applications in biomedical imaging, autonomous systems and optical computing.	7

Text Book

1. **Amnon Yariv**, *Quantum Electronics*, **3rd Edition**, John Wiley & Sons.

Reference Books

1. **B. B. Laud**, *Lasers and Non-linear Optics*, **4th Edition**, New Age International Publishers.
2. **Orazio Svelto**, *Principles of Lasers*, **5th Edition**, Springer.
3. **William T. Silfvast**, *Laser Fundamentals*, **2nd Edition**, Cambridge University Press.
4. **Bahaa E. A. Saleh** and **Malvin Carl Teich**, *Fundamentals of Photonics*, **3rd Edition**, Wiley.
5. **S. O. Kasap**, *Optoelectronics and Photonics: Principles and Practices*, **2nd Edition**, Pearson