Anekant Education Society's

Tuljaram Chaturchand College, Baramati

(Autonomous)

Two Year Degree Program in Electronics

(Faculty of Science & Technology)

CBCS Syllabus

M.Sc. (Electronics) Part-I Semester -II

For Department of Electronics

Tuljaram Chaturchand College, Baramati

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2023-2024

Title of the Programme: M.Sc. (Electronics)

Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Electronics and related subjects, the Board of Studies in Electronics at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the first semester of M.Sc. Part-I Electronics, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and the Circular issued by SPPU, Pune on 31st May 2023.

A Electronics degree equips students with the knowledge and skills necessary for a diverse range of fulfilling career paths. Post Graduates in Electronics find opportunities in various fields, including Embedded System developer, IoT, IT, AI developer, WSN, MatLab

Developer, PCB Designer, Communication Sector, Defence, Sensor and System developer, PLC and SCADA developer, Lab View and many other domains.

The curriculum also delves into the intricate relationship between Industry and atomization. The objectives of updating syllabi is to prepare pupils to face the current challenges in Industry and Academia, to develop strong footprint in the fundamental, specialization and recent technology. The proposed syllabus and scheme of study equip students with both basic and advance topics in the field of Electronics. In addition, the syllabus incorporate more practical and working principles, design guidelines and experimental skills associated with different semiconductor devices and circuits, underlying mathematical and analysis techniques, electromagnetic and instrumentation principles, design methodologies for digital and embedded systems, communication electronics and control systems and various applications of electronic devices, circuits and systems are among such important aspects.

Overall, revising the Electronics syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

Programme Specific Outcomes (PSOs)

PSO1: Acquire the knowledge in Electronic Devices and Circuits, Advanced Microcontroller, Embedded systems, AI, WSN , MEMS and other core areas of Electronics, Sensors and Instrumentation, Antenna.

PSO2: Understand the principles and working of both hardware and software aspects of Electronic systems

PSO3: Gain theoretical and practical knowledge in developing areas of Electronics.

PSO4: To analyze, design and implement analog and digital electronic systems, Antenna and communication systems.

PSO5: Assess the impact of new technologies and solve complex problems.

PSO6: Develop research oriented skills and to inculcate laboratory skills in students so that they can take up independent projects.

Anekant Education Society's

Tuljaram Chaturchand College, Baramati

(Autonomous)

Board of Studies (BOS) in Electronics

From 2022-23 to 2024-25

Sr. No.	Name	Designation
1.	**Dr. Deshpande J. D.**	**Chairman**
2.	**Dr. Mrs. Pawar A. M.**	**Member**
3.	**Dr. Patil S. N.**	**Member**
4.	**Mrs. Rupnawar P. D.**	**Member**
5.	**Dr. Kothawale A. S.**	**Member**
6.	**Mrs. Gawade S. A.**	**Member**
7.	**Mrs. Patil S. S.**	**Invitee**
8.	**Mrs. Shinde P. K.**	**Invitee**
9.	**Mrs. Adsul K. R.**	**Invitee**
10.	**Prof. Dr. S. R. Kumbhar**	**Expert from other University**
11.	**Dr. Sadistap Shashikant**	**Expert from other University**
12.	**Dr. Mudassar Shaikh**	**Expert from University**
13.	**Mr. Patil Sharad. V.**	**Industry Expert**
14.	**Miss. Salunkhe Yogita.**	**Meritorious Alumni**
15.	**Miss Gawade Shivanjali Shantaram**	**Student Representative**
16.	**Miss. Shedge Dhanashri Nitin**	**Student Representative**
17.	**Mr. Mahamuni Mayur Ganesh**	**Student Representative**

Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(Autonomous)

Credit Distribution Structure for (M.Sc. Electronics) Part-I (2023 Pattern)

Year	Level	Sem.	Major		Research Methodology (RM)	OJT/ FP	RP	Cum. Cr.
			Mandatory	Electives				
I	6.0	Sem-I	ELE-501-MJM: Mathematical Methods in Electronics and Network Analysis (Credit 04) ELE-502-MJM: Integrated Circuit Analysis. (Credit 04) ELE-503-MJM: Electronics Science Practical Course -I (Credit 02) ELE-504-MJM: Electronics Science Practical Course -II (Credit 02)	ELE-511-MJE(A): A. Digital System Design using Verilog. (Credit 04) OR ELE-512-MJE(B): B. Advanced 'C' and JAVA Programming. (Credit 04)	ELE-521-RM Research Methodology (**Credit 04**)	--	--	**20**
		Sem- II	ELE-551-MJM: Electromagnetics, Microwave and Antennas.(Credit 04) ELE-552-MJM: Embedded System Design with PIC Microcontroller. (Credit 04) ELE-553-MJM:: Electronics Science Practical Course -III (Credit 02) ELE-554-MJM:: Electronics Science Practical Course - IV (Credit 02)	ELE-561-MJE(A): A. Instrumentation and Measurement Techniques. (**Credit 04**) OR ELE-562-MJE(A): Foundation of Semiconductor Devices (**Credit 04**)	--	ELE-581-OJT/FP **Credit 04**	--	**20**
Cum. Cr.			**24**	**8**	**4**	**4**	**--**	**40**

Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati (Autonomous)

Course Structure for (M.Sc. Electronics) Part-I (2023 Pattern)

Sem.	Course Type	Course Code	Course Title	Theory/ Practical	No. of credits
I	Major (Mandatory)	ELE-501-MJM	Mathematical Methods in Electronics and Network Analysis	Theory	04
	Major (Mandatory)	ELE-502-MJM	Integrated Circuit Analysis	Theory	04
	Major (Mandatory)	ELE-503-MJM	Electronics Science Practical Course -I	Practical	02
	Major (Mandatory)	ELE-504-MJM	Electronics Science Practical Course -II	Practical	02
	Major (Elective)	ELE-511-MJE(A)	A- Digital System Design using Verilog	Theory	04
		ELE-512-MJE(B)	B- Advanced 'C' & JAVA Programming.	Theory	
	Research Methodology (RM)	ELE-521-RM	Research Methodology	Theory	04
				Total credits Semester I	**20**
II	Major (Mandatory)	ELE-551-MJM:	Electromagnetics, Microwave and Antennas.	Theory	04
	Major (Mandatory)	ELE-552-MJM:	Embedded System Design with PIC Microcontroller.	Theory	04
	Major (Mandatory)	ELE-553-MJM:	Electronics Science Practical Course -III	Practical	02
	Major (Mandatory)	ELE-554-MJM:	Electronics Science Practical Course - IV	Practical	02
	Major (Elective)	ELE-561-MJE(A):	A: Instrumentation and Measurement Techniques.	Theory	04
	Major (Elective)	ELE-562-MJE(B)	B: Foundation of Semiconductor Devices	Theory	
	On Job Training (OJT)/Field Project (FP)	ELE-581-OJT/FP	On Job Training Filed Project	Training/Project	04
				Total credits Semester II	**20**
				Cumulative Credits Semester I and II	**40**

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the Programme : M.Sc.Electronics

Programme Code : **PSELE**

Class : M.Sc. I

Semester : II

Course Type : Major Mandatory (Theory)

Course Code : ELE-551-MJM

Course Title : Electromagnetics, Microwave and Antennas.

No. of Credits : 04

No. of Teaching Hours : 60

Course Objectives:

1. To introduce to students the concepts of electromagnetics
2. To understand the theory of transmission lines and wave guides
3. To understand basics of Smith Chart
4. To Understand working of OFC
5. TO Study Different Antenna types.
6. To study various parameters of antennas
7. To study various methods of generation of microwaves.

Course Outcomes:

By the end of the course, students will be able to:

CO1. From this course, the students are expected to learn Concept of Electromagnetic Waves.
CO2. Know various types of transmission line.
CO3. Students will Solve problem using Smith Chart.
CO4. Know the Working of OFC.
CO5. Test and examine the phenomena of wave propagation in different media and its interfaces.
CO6. Design different antennas based on their characteristics for different applications.
CO7. Understanding various method of generation of microwaves

Topics and Learning Points

Unit-1: Electromagnetic Waves (15L)

Review of Maxwell's equations and their meaning, continuity equation, electric and magnetic wave equations in time domain and frequency domain, wave propagation in conducting and non-conducting media, skin depth and high frequency propagation, boundary conditions at the interface between two mediums, Poynting theorem and its applications.

Unit-2: Transmission Lines (15L)

Types of transmission lines, microstrip lines, two wire transmission line, transmission line equations for voltages and currents, inductance and capacitance per unit length of two wire and coaxial cable transmission line, characteristic impedance, propagation constants, attenuation and phase constants, phase velocity, reflection and transmission coefficients, SWR, line impedance, normalized impedance and admittance, Smith chart construction and applications, single stub and double stub matching, applications to reflection of EM-waves at interfaces for normal incidence.

Unit-3: Waveguides and Components (15L)

Concept of waveguides, frequency range, relation to transmission lines.

Rectangular Waveguides: TM and TE Modes, concept of cut-off frequency, guide impedance, phase velocity, guide wavelength for TE and TM modes, Applications to TE mode in rectangular waveguide, power losses in rectangular waveguide, introduction circular waveguide.

Optical Fiber: principles of operation and construction, difference between conducting circular waveguide and fiber Different methods of excitation of TE and TM modes in waveguides Cavity Resonators, Q factor of cavity resonators

Unit-4: Electromagnetic Radiation (15L)

Potentials of electromagnetic fields, retarded potential, radiation from oscillating dipole, concept of near zone and radiation zone, radiation resistance, role of antenna in exciting different TE, TM modes in wave guides.

Antenna Parameters: gain, directivity, power, aperture, Friis equation, radiation pattern.

Application Areas: antenna temperature, Signal to Noise Ratio (SNR), remote sensing, RADAR equation.

Antennas Types: $\lambda/2$ antenna, antenna arrays, horn antennas, parabolic dish antennas, Endfire antenna – Yagi Uda, patch antenna, microstrip antennas EMI and EMC.

Generation of Microwaves: principle, physical structure and working of-Gunn Effect diodes, magnetron oscillator, reflex Klystron oscillator.

Reference Books:

1. Microwave Devices and Circuits, Samuel Y. Liao, PHI, 3rd Edition, 2002.
2. Principles of Electromagnetics, N. Sadiku, Oxford University Press.
3. Electromagnetics with Applications, Kraus and Fleiseh, McGraw Hill, 5th Edn, 1999.
4. Electromagnetics, J.D. Kraus, 4th Edn, McGraw Hill, 1992.

Course Outcome	Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	-	2	1	1	-	-	-
CO2	2	3	3	2	1	2	2	2	1
CO3	2	1	2	-	-	-	-	1	-
CO4	3	3	3	2	1	2	-	1	1
CO5	1	1	1	3	-	1	-	-	-
CO6	2	2	2	3	-	-	-	1	1
CO7	1	3	1	3	-	-	-	-	-

Justification for the mapping

PO1: Disciplinary Knowledge

CO1 to CO7: All include Disciplinary Knowledge

PO2:Critical Thinking and Problem solving

CO1 to CO7: All Co include Critical Thinking and Problem solving.

PO3: Social competence

CO2: Understanding the theory of transmission lines and wave guides equips students with essential knowledge for collaborative work in the telecommunications and signal processing sectors.

CO3 to CO7:All include Social competence.

PO4: Research-related Skills and Scientific Temper

CO1 to CO7(Except CO3):it include Research-related Skills and Scientific Temper

PO5: Trans-disciplinary knowledge

CO1: A solid understanding of electromagnetics is foundational across multiple disciplines.

CO2: The theory of transmission lines and wave guides is crucial not only in electronics but also in telecommunications, guiding the efficient transfer of signals

CO4: Working of OFC include Trans-disciplinary knowledge

PO6: Personal and professional competence

CO1: Introducing students to electromagnetics forms the foundational knowledge necessary for personal and professional competence.

CO2: Understanding the theory of transmission lines and wave guides is essential for personal and professional competence

CO4: Understanding the working of OFC is crucial for personal and professional competence in the field of communication engineering.

CO5: Studying different antenna types contributes to personal and professional competence by providing students with the knowledge needed for effective antenna design

P07: Effective Citizenship and Ethics

CO2: The theory of transmission lines and wave guides is crucial not only in electronics but also in telecommunications is Effective Citizenship and Ethics

PO8: Environment and Sustainability:

CO2: Study of transmission line include Environment and Sustainability

CO3: By studying different chart we get Sustainability

CO4:Study of OFC include Sustainability

CO6: The study of various parameters of antennas includes understanding the materials used in their construction

PO9: Self-directed and Life-long Learning

CO2,CO4 ,CO6: the course outcomes contribute to self-directed learning by encouraging students to explore foundational concepts in electromagnetics and its applications

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the Programme : M.Sc.Electronics

Programme Code : **PSELE**

Class : M.Sc. I

Semester : II

Course Type : Major Mandatory (Theory)

Course Code : ELE-552-MJM

Course Title : Embedded System Design with PIC Microcontroller.

No. of Credits : 04

No. of Teaching Hours : 60

Course Objectives:

1. To understand the basics of embedded system.
2. To learn communication standards and protocols and RTOS.
3. To understand the architecture of PIC microcontrollers.
4. To learn embedded C and assembly language programming.
5. To learn real interfacing devices to microcontroller.
6. To introduce real life modules.
7. To study application of Embedded system using PIC.

Course Outcomes:

By the end of the course, students will be able to:

CO1. Understand the internal architecture and interfacing of different peripheral devices with Microcontrollers

CO2: Analyze and develop embedded hardware and software development cycles and tools.

CO3: Evaluate and understand different concepts of sensors, memory interface, and types of communication protocols.

CO4: Design and develop programming skills in embedded systems for various applications.

CO5: Interface external devices to microcontroller.

CO6: Understand the concept of embedded system design.

CO7: Explain application of Embedded system using PIC.

Topics and Learning Points

Unit-1: Introduction to Embedded System and Bus Standards (15L)

Embedded System: components, examples, development cycle of embedded system
Development Environment - algorithm, flow chart, IDE, ICE, programmer.
Communication Protocols: I2C bus- specification, general characteristics, bus signals, address Mechanism.

Serial Peripheral Interface (SPI): specifications, master slave configuration,
Controller Area Network (CAN): specifications, basic concepts, frame types, bus signals.

Unit-2: Introduction to PIC Microcontroller (15L)

Architecture (PIC18F4550, 18F458), instruction set, addressing modes, memory organization, timers, I/O ports, ADC, interrupts.
Design of General Purpose Target Board: reset, oscillator circuit, derivatives of PIC.
Basic C Programs: arithmetic, logical, code converter, block data transfer, I/O programming.

Unit -3: Interfacing programming (15L)

Embedded C programming for timers and counters, ADC, DAC, LED, SSD and LCD displays (text and graphic), keyboard and motors, EEPROM, GPS, GSM.

Unit -4: Designing Embedded Systems using PIC (15L)

Home Automation, Automatic Room temperature controller, IoT based Home Automation, Gas Detector, Environment Monitoring system, Heartbeat monitoring system, Auto irrigation system.

References:

1. Embedded/ Real Time System - Concept Design Programming, KVVK Prasad
2. PIC Microcontroller and Embedded Systems, Mazidi, Mckinlay and Causey, Pearson Education.
3. Programming PIC microcontrollers with PIC basic by Chuck Helebuyck
4. PIC microcontrollers-programming in basic by Milan Verle.
5. C Programming for Embedded Systems, Kirk Zurell, PearsonEducation.

Course Outcome	Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	3	3	3	3	2	3	3
CO2	3	2	2	3	3	3	1	1	2
CO3	3	3	1	3	3	2	-	1	3
CO4	3	3	2	3	3	3	1	1	3
CO5	3	3	3	3	3	3	-	-	3
CO6	3	3	1	3	3	-	-	-	2
CO7	3	3	-	3	3	3	2	3	3

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Providing a solid foundation in understanding the core concepts and functionalities of embedded systems.
CO2: Delving into the comprehensive understanding of the tools and processes involved in embedded system development.
CO3: Ensuring a broad understanding of essential elements crucial in embedded systems design.
CO4: Empowering students with the practical skills required for implementing embedded solutions across diverse applications.
CO5: Providing hands-on experience in connecting and integrating external components into embedded systems.
CO6: Instilling a holistic understanding of the principles and methodologies involved in creating effective embedded systems.
CO7: Applying PIC-based embedded systems in automated control systems demonstrates proficiency in control systems engineering principles..

PO2: Critical Thinking and Problem solving

CO1: Integrate components effectively into a microcontroller-based system.
CO2: Optimize development processes and solve challenges associated with designing embedded systems.
CO3: Choose and implement the most suitable solutions, solving problems associated with data acquisition and communication in embedded systems.
CO4: Solve programming challenges and create efficient solutions for diverse applications.
CO5: Troubleshoot and solve issues related to compatibility, connectivity, and data transfer between the microcontroller and external components.
CO6: Solve complex problems associated with integrating hardware and software components seamlessly.
CO7: Designing algorithms for real-time control involves critical thinking and problem-solving skills. Designing control algorithms for precise medical processes requires critical thinking.

PO3: Social competence

CO1: Enabling effective communication and collaboration in the field of embedded systems.
CO2: Fostering teamwork and shared understanding among individuals working on embedded systems projects.
CO3: Enhances social competence by facilitating effective communication with peers, stakeholders, and other professionals in the embedded systems domain.
CO4: Enabling individuals to contribute effectively to collaborative projects and share their expertise with others in the field.
CO5: Enabling effective collaboration and communication with team members and stakeholders involved in the development of embedded systems.
CO6: Facilitating communication and collaboration among team members, fostering a shared understanding of design principles and objectives.

PO4: Research-related skills and Scientific temper

CO1: Delving into the intricate details of microcontroller architecture and peripheral interfacing, fostering a scientific temper essential for comprehensive understanding and exploration in embedded systems.

CO2: Analyzing and developing embedded hardware and software cycles requires a research-oriented approach, cultivating research-related skills and a scientific temper to innovate and improve development methodologies.
CO3: Evaluation and understanding of sensor concepts, memory interfaces, and communication protocols involve research skills, contributing to a scientific temper necessary for critical assessment and improvement of these concepts.
CO4: The design and development of programming skills in embedded systems demand research-oriented exploration and innovation, aligning with the development of scientific temper and research-related skills.
CO5: Involves understanding, experimenting, and innovating to enhance the efficiency and applicability of these interfaces.
CO6: Exploring various design methodologies and a scientific temper for critical analysis and improvement of existing practices.
CO7: Designing and implementing PIC-based embedded systems for industrial automation requires research skills and a scientific temper to stay abreast of technological advancements and optimize system performance.

PO5: Trans-disciplinary knowledge

CO1: Transcends traditional disciplinary boundaries, incorporating insights from multiple fields for a holistic understanding.
CO2: Involves integrating knowledge from diverse domains, emphasizing a trans-disciplinary approach to enhance the effectiveness of development cycles.
CO3: Evaluation and understanding of sensor concepts, memory interfaces, and communication protocols necessitate knowledge that spans various disciplines, promoting a trans-disciplinary perspective in the exploration of these concepts.
CO4: Involves drawing upon knowledge from various domains, highlighting the trans-disciplinary nature of embedded systems.
CO5: Interfacing external devices to microcontrollers requires knowledge that spans different disciplines, showcasing the trans-disciplinary nature of integrating various devices into a cohesive system.
CO6: Grasping the concept of embedded system design entails incorporating knowledge from multiple disciplines, emphasizing the trans-disciplinary approach necessary for effective system design.
CO7: Integrating PIC microcontrollers into industrial automation systems involves trans-disciplinary knowledge, considering aspects of electronics, control systems, and communication protocols for a comprehensive solution.

PO6: Personal and professional competence

CO1: Fosters personal and professional competence by enhancing technical expertise and problem-solving skills.
CO2: Honing skills related to system development and problem-solving within the embedded systems domain.
CO3: The evaluation and understanding of sensor concepts, memory interfaces, and communication protocols contribute to personal and professional competence, providing a well-rounded skill set for designing and implementing embedded systems.
CO4: Enhances personal and professional competence by cultivating proficiency in creating solutions for various contexts.
CO5: Developing skills in integrating external components into embedded systems for specific functionalities.

CO7: Developing reliable and efficient industrial automation solutions with PIC demonstrates personal and professional competence in embedded systems engineering.

PO7: Effective Citizenship and Ethics

CO1: Fosters effective citizenship by ensuring responsible and ethically sound use of technology for societal benefit.
CO2: Analyzing and developing embedded hardware and software cycles with ethical considerations contributes to effective citizenship by promoting responsible and ethical practices in technology development.
CO4: Ensuring that the applications benefit society without causing harm or ethical concerns.
CO7: Employing embedded systems for precise control in industrial processes showcases effective citizenship by contributing to productivity and efficiency while adhering to ethical engineering practices.

PO8: Environment and Sustainability

CO1: Optimizing resource usage and minimizing environmental impact in microcontroller applications.
CO2: Creating energy-efficient and environmentally friendly embedded systems.
CO3: Ethical evaluation of sensor concepts, memory interfaces, and communication protocols includes considerations for sustainability, ensuring responsible resource use and environmental impact.
CO4: Designing and developing programming skills with a focus on efficiency and resource optimization contributes to sustainability by creating eco-friendly embedded systems.
CO7: Implementing embedded systems in industrial automation using PIC may contribute to sustainability by optimizing energy usage and reducing waste through efficient control processes.

PO9: Self-directed and Life-long learning

CO1: Acquiring knowledge of microcontroller architecture and interfacing fosters a self-directed and lifelong learning attitude, allowing continuous adaptation to emerging technologies.
CO2: Enabling the continuous improvement of hardware and software development skills throughout one's career.
CO3: Continuous evaluation and understanding of sensor concepts, memory interfaces, and communication protocols promote a self-directed and lifelong learning approach in adapting to evolving technologies.
CO4: The constant pursuit of designing and developing programming skills in embedded systems encourages a self-directed and lifelong learning attitude, crucial for staying relevant in the ever-evolving field.
CO5: Adapting to diverse hardware requirements over time.
CO6: Grasping the concept of embedded system design is a foundation for self-directed and lifelong learning, enabling individuals to navigate and contribute to varied design challenges throughout their professional journey.
CO7: Adapting to evolving industrial automation requirements and incorporating new technologies reflects self-directed learning and a commitment to life-long learning in embedded systems engineering.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the Programme : M.Sc.Electronics

Programme Code : **PSELE**

Class : M.Sc. I

Semester : II

Course Type : Major Mandatory(Practical)

Course Code : ELE-553-MJM

Course Title : Electronic Science Practical Course -III

No. of Credits : 02

No. of Teaching Hours : 30

Course Objectives:

1. To understand the basics operation of transducers.
2. To learn interfacing of transducers and sensors.
3. To understand the counter circuits.
4. To learn antenna parameters.
5. To learn microwave devices and source.
6. To learn RPM measurement techniques.
7. To study various instrumentation amplifier for sensor interfacing.

Course Outcomes:

By the end of the course, students will be able to:

CO1. Learn the different types, working principle of active and passive transducers.
CO2. Experiment analog electronic circuits using different sensors and Transducers.
CO3. Evaluate different electronic circuits and review the analog and digital circuits.
CO4. Develop ability to design, build and test analog/digital application circuits.
CO5. To know operation of different instruments and antenna elements.
CO6. Ability to study antenna parameters and radiation pattern
CO7. To know operation of microwave test bench application
CO8. Capability to develop experimental skills, analyzing the results and interpret data.

Topics and Learning Points (Perform any 8 experiments)

[A] Practical based on Instrumentation and Measurement System

1. Design build and test rms to dc converter for voltage measurement of ac signal
2. Displacement measurement using LVDT, signal conditioning and DPM
3. Temperature measurement using PT100, signal conditioning and DPM
4. Temperature measurement using thermocouple with cold junction compensation

5. Design build and test IR transmitter and receiver (TSOP1738 or similar) for object detection
6. To build and test current telemetry (4 to 20mA)
7. Ultrasonic transmitter and receiver, distance measurement
8. Pressure measurement using strain gauge
9. RPM measurement using various methods
10. Design light intensity meter using photodiode or LDR and the necessary signal conditioning and display.
11. Use of strain gauge to measure stress on a cantilever made of material known quantity
12. Study of PIR Sensor.

[B] Practical based on Electromagnetics, Microwaves, Antennas

1. To study the characteristics of Klystron tube
2. To determine the standing wave ratio and reflection coefficient of a given waveguide
3. To measure an unknown impedance with smith chart
4. To determine the frequency and wavelength in rectangular waveguide
5. To study the characteristics of directional coupler
6. Design and test Yagi-Uda antenna with power reflectors
7. experiment demonstration of Half wave dipole antenna
8. Study of Radiation pattern of Different Antenna
9. Measurement of primary-secondary coupling factor of a given transformer using LCR meter (calculation of transformer model parameters expected)

Activity: (Any one Activity equivalent to two experiments)

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

Course Outcome	Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	2	2	-	-	-	-	-	-
CO2	3	2	2	3	2	2	-	2	2
CO3	-	2	-	2	-	-	-	-	-
CO4	2	2	2	2	-	2	3	2	2
CO5	1	2	-	2	-	-	-	-	-
CO6	1	2	-	2	-	-	-	-	1
CO7	3	2	-	3	-	2	-	-	-

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Students will able to demonstrate working and use of transducer, which helpful for development of application.
CO2: Students will able to develop analog design for sensor and transducer for dedicated application. This is a strong relation.
CO4: Students will master in analog and digital design for hardware.
CO5: Students will develop knowledge to demonstrate the various instruments performance, use and antenna working.
CO6: Students will demonstrate the use of test bench and microwave application.
CO7: Students will be able to develop capability develop hardware and discussion result.

PO2: Critical Thinking and Problem Solving

CO1: Students will apply their knowledge for selecting transducer for specific application.
CO2: Students will think to develop specific analog design using sensor and transducer for dedicated application.
CO3: Student will think to develop system for observing the problem.
CO4: Students will use their knowledge for solving complex analog and digital hardware design.
CO5: Students will apply their knowledge for use of instruments for diverse application with reduced error.
CO6: Students will use their understanding to use of microwave frequency, microwave test bench for various applications.
CO7: Students will increase thinking ability to develop experimental skill to design electronics system for diverse field problem solving.

PO3: Social competence

CO1: Students will able to write idea or communicate the use of sensors and transducers for industrial, agriculture, medical, automobile or any other relevant application.
CO2: Student will apply the idea to exhibit the hardware design for required field.
CO4: Student will use their knowledge for design analog, digital or combination circuit for dedicated application to solve real-world problems.

PO4: Research-related skills and Scientific temper

CO2,3,4: Student develop their ability to think need of sensor and transducers and design necessary circuit.
CO5: Students will able to use scientific instruments for result analysis and standardisation.
CO6,7: Students apply their knowledge for antenna design.

PO5: Trans-disciplinary knowledge

CO2: Student will use their knowledge for designing electronic system for solving practical problems interdisciplinary field.

PO6: Personal and professional competence

CO2,4,7: Students to develop their ability to work independently or as a team to solve real-world problems. Students develop their skills for starting own start-up in electronics design.
Students use their knowledge to develop suitable solution for interdisciplinary field such as physics, chemistry, agriculture, industrial, botany etc.

PO7: Effective Citizenship and Ethics

CO4: Student will demonstrate the use of technology for smart work and aware the need of technology.

PO8: Environment and Sustainability

CO4,6: Student will think to develop system for environmental parameter monitoring system which help various applications, energy conservation.

PO9: Self-directed and Life-long learning

CO2,4,6: Student will think the technical solution for real-world problems and start-up in electronics design for various application. It is lifelong learning due to technology up gradation.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the Programme : M.Sc. Electronics

Programme Code : **PSELE**

Class : M.Sc. I

Semester : II

Course Type : Major Mandatory (Practical)

Course Code : ELE-554-MJM

Course Title : Electronic Science Practical Course -IV

No. of Credits : 02

No. of Teaching Hours : 30

Course Objectives:

1. To understand the basics of embedded C programming.
2. To learn communication standards and protocols.
3. To understand the interfacing of PIC microcontrollers.
4. To learn real interfacing devices to microcontroller.
5. To study MATLAB command for communication and simulation.
6. To understand the use of MATLAB for antenna parameter design.
7. To learn directivity pattern of antenna.

Course Outcomes:

By the end of the course, students will be able to:

1. To understand specifications of PIC microcontroller.
2. To understand architecture of PIC microcontroller.
3. To learn the skills for programming the PIC microcontroller.
4. To interface different devices to PIC microcontroller.
5. To study serial communication interface with PIC.
6. To study the fundamentals of MATLAB.
7. To adopt the useful skills for MATLAB programming.
8. To use the MATLAB for simulation purpose in different subjects of electronics.

Topics and Learning Points (Perform any 8 experiments)

Group A - Practical on PIC Interfacing.

1. Interfacing of LED array to generate different sequences, use of timer for delay generation.
2. Two-digit 7-segment display (multiplexed) interfacing.
3. LCD / keyboard Interfacing.

4. Bidirectional stepper motor interfacing. Real Time Clock display on LCD / Hyper Terminal (I2C).
5. Use of internal EEPROM.
6. DAC interfacing (square wave, staircase, triangular, sine) use of timer.
7. Voltage measurement using ADC interfacing and display on LCD.
8. Two digit frequency counter or event counter using timer /interrupt.
9. Matrix keyboard / Touch screen interfacing.
10. Graphic LCD interfacing.
11. Zigbee communication.
12. DC motor control using PWM / intensity control of LED.

Group B- Practical on Electromagnetics (C / MATLAB)

1. To plot Equipotential contours and field lines for given charge distribution.
2. Use of Smith chart for transmission line pattern and verify using C.
3. Use of MATLAB for potential distribution in a region bound by two conductors.
4. Use of MATLAB for directivity pattern for simple antennas.
5. Use of MATLAB to plot the contours of the voltage and the field lines for square coaxial cable.
6. Use of MATLAB to plot magnetic field lines of solenoids.
7. Use of MATLAB to determine electric field at a point.

Activity: (Any one Activity equivalent to two experiments)

Students must perform at least one additional activity out of two activities in addition to eight experiments mentioned above. Total Laboratory work with additional activities should be equivalent to ten experiments.

Industrial Visit / Study Tour.

Course Outcome	Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	2	3	-	-	-	-	2
CO2	2	2	-	2	-	1	-	-	
CO3	3	2	2	3	-	-	-	-	2
CO4	3	3	-	2	1	2	2	1	2
CO5	2	-	2	2	-	1	-	-	1
CO6	3	2	2	1	-	-	-	-	1
CO7	3	2	2	2	-	2	2	-	2

Justification for the mapping

PO1 Disciplinary Knowledge

CO1: Providing a foundational understanding of the core features and capabilities of PIC microcontrollers, essential for effective utilization in electronic applications.
CO2: Delving into the internal structure and organization of the microcontroller, forming the basis for informed decision-making in its application.
CO3: Imparting the essential skills required for effective utilization and control of PIC microcontrollers in electronic systems.
CO4: Providing hands-on experience in connecting and integrating external components with the microcontroller, an integral part of electronic system design.
CO5: Exploring the principles and methods of serial communication, essential for effective data exchange in electronic systems.
CO6: Introducing a versatile tool widely used in electronics for modeling, simulation, and analysis, enhancing students' capabilities in electronic system design.
CO7: Providing the necessary programming skills to effectively utilize MATLAB for electronic system simulation and analysis.
CO8: Applying simulation techniques to analyze and understand electronic systems, enhancing students' competence in the field.

PO2: Critical Thinking and Problem solving

CO1: To assess and apply technical specifications effectively in electronic system design.
CO2: Analyze and comprehend the intricate internal structure, facilitating informed decision-making in system design.
CO3: Addressing challenges in coding, debugging, and optimizing the program for efficient operation.
CO4: Effectively integrate diverse components and troubleshoot potential issues in the hardware interface.
CO6: Understand and apply MATLAB tools for modeling and simulation in electronic system analysis and design.
CO7: Address challenges in coding, debugging, and optimizing MATLAB programs for effective simulation in electronic system studies.
CO8: Apply simulation techniques effectively, enabling a deeper understanding of electronic systems.

PO3: Social competence:

CO1: It often requires collaboration and communication to gather and interpret technical information within a team or with peers.
CO3: Encourages collaboration and knowledge-sharing among peers, providing opportunities for mutual learning and skill development.
CO5: Encouraging collaborative learning and communication, as students share insights and problem-solving strategies related to communication protocols.
CO6: Facilitating collaborative exploration and discussion among students when tackling MATLAB-related challenges and sharing knowledge.
CO7: Fostering collaboration and collective problem-solving as students work together to enhance their programming capabilities in MATLAB.
CO8: Creating an environment where students can collaborate, share insights, and collectively solve challenges related to simulation and analysis.

PO4: Research-related skills and Scientific Temper

CO1: Encouraging students to critically analyze and explore the technical details, promoting a research-oriented approach to learning.
CO2: Delving into the internal structure, fostering a mindset for systematic analysis and inquiry into microcontroller design principles.
CO3: Students engage in systematic problem-solving and algorithmic thinking, contributing to a research-oriented mindset.
CO4: Encouraging students to explore and experiment with hardware integration, promoting a scientific approach to device interfacing.
CO5: Delving into communication protocols, fostering a systematic and analytical approach to understanding and implementing serial communication.
CO6: Students use MATLAB as a tool for scientific analysis, simulation, and modeling in electronic systems.
CO7: Encouraging students to apply systematic coding practices, fostering a research-oriented mindset in utilizing MATLAB for electronic system analysis.
CO8: Integrating a scientific approach to simulation, analysis, and modeling within the MATLAB environment.

PO5: Trans-disciplinary knowledge:

CO4: Integrating diverse components, connecting electronic hardware with various sensors and actuators, and creating a holistic understanding of system integration.

PO6: Personal and professional competence

CO2: Fostering a deep understanding of microcontroller design principles, facilitating effective problem-solving and decision-making in a professional context.
CO4: Encouraging teamwork, effective communication, and the ability to integrate diverse components, reflecting essential skills in a professional setting.
CO5: Enhancing communication skills and providing knowledge essential for effective collaboration in the field of electronics.
CO7: Providing practical programming skills applicable to professional contexts, ensuring individuals are well-prepared for real-world applications.
CO8: Applying simulation techniques to analyze and understand electronic systems, contributing to skills necessary for a successful career.

PO7: Effective Citizenship and Ethics:

CO4: Emphasizing ethical considerations and responsible practices in hardware integration, considering the societal impact of interconnected devices.
CO7: Providing students with the ethical foundation needed for responsible coding practices, aligning with ethical standards in software development.

PO8: Environment and Sustainability:

CO4: Encouraging efficient hardware integration, aligning with eco-friendly practices in electronic device connectivity.

PO9: Self-directed and Life-long learning:

CO1: Encouraging students to continuously update their knowledge about evolving microcontroller technologies throughout their professional careers.
CO3: Establishing a foundation for continuous skill development, empowering students to adapt to emerging programming paradigms in embedded systems.

CO4: Prompting students to stay informed about diverse electronic components and interface technologies, fostering a commitment to continuous learning.
CO5: Urging students to stay updated on communication protocols and adapt to new standards, aligning with a commitment to lifelong learning.
CO6: Introducing a versatile tool, encouraging students to explore its applications across various domains and adapt to evolving uses throughout their careers.
CO7: Providing students with a foundation in programming applicable across disciplines, enabling them to independently explore advanced MATLAB applications over time.
CO8: Empowering students to explore diverse simulation applications, fostering a commitment to continuous learning in electronic system simulation.

CBCS Syllabus as per NEP 2020 for M.Sc. I (2023 Pattern)

Name of the Programme : M.Sc. Electronics

Programme Code : **PSELE**

Class : M.Sc. I

Semester : II

Course Type : Elective (Theory)

Course Code : ELE-561(A)-MJE

Course Title : Instrumentation and Measurement Techniques.

No. of Credits : 04

No. of Teaching Hours : 60

Course Objectives:

1. To understand the configurations and functional descriptions of measuring instruments.
2. To understand the basic performance characteristics of instruments
3. To understand the working principles of various types of sensors and transducers and their use in measuring systems.
4. To study the techniques involved in various types of instruments.
5. To understand the relevance of electronics with other disciplines.
6. To understand the application of Electronics in biomedical application.
7. Ability to bring out the important and modern methods of imaging techniques and their analysis.

Course Outcomes:

By the end of the course, students will be able to:

CO1. To Know the various types instruments and measurement system.
CO2. Ability to find Instrument characteristics and error.
CO3. Working principles of various types of sensors and transducers, Actuators Instruments.
CO4. Ability to bring out the importance of Sensors for monitoring controlling applications.
CO5. Ability to interface sensors actuators for dedicated applications.
CO6. To know the role of technology in biomedical applications.
CO7. Students are able to know the bio potential, ECG, EEG & EMG.
CO8. Ability to bring out the important and modern methods of imaging techniques and their analysis.
.

Topics and Learning Points

Unit1: Introduction to Instrument and Measurement Systems (15L)

Definition and significance of measurement, classification of instruments and types of measurement applications, elements of an instrument / measurement system

Static and dynamic characteristics: Accuracy, Precision, Resolution, Threshold, Sensitivity, Hysteresis, loading effect, linearity, dead zone.

Errors in measurement: Types of Errors - gross, systematic, environmental errors, Systematic errors, computational error, personal error etc.

Unit 2: Sensors and Transducers (15L)

Definition, Types of sensor, classification, Need of Sensors.

Transducer: Active and passive transducer, characteristics of sensors, static and dynamic characteristics, Methods of transduction, primary sensing elements and transducers, electrical transducers, classification of transducers.

Motion and dimensional measurement: relative displacement- translational and rotational, resistive potentiometers, resistance strain gauge, differential transformers- LVDT & RVDT, piezoelectric transducers, digital displacement transducers (translational and rotary encoders), ultrasonic transducers, Hall effect sensor.

Temperature Sensors: Thermocouples, Thermistors, RTD, PT 100, Semiconductor temperature transducers, AD590, LM35, LM135, LM235, LM335.

Actuators: Electromagnetic relay, Limit switch, Proximity sensor, Inductive, Capacitive, IR proximity sensor.

Case Studies: Designing of instrumentation for measurement of a) Temperature b) Humidity. · Interfacing of PIR and ultrasonic sensor modules.

Unit 3: Process Parameter Measurement (15L)

Force, Torque and Shaft power: standards and calibration, basic methods of Strain gauge, digital system, load cell, torque measurement on rotating shafts

Pressure and Sound Measurement: dead weight gauges and manometers, low pressure measurement - Mcload gauge, Sound level meter, microphone, and capacitor microphone

Flow measurement: Pitot-static tube, Yaw tube, hot wire and hot film anemometers, Flow Rate-rotameter, ultrasonic flow meter, electromagnetic flow meters

Radiation Fundamentals: detectors, optical pyrometers, IR imaging systems
Flux sensing- slug type sensors,

Unit4: Biomedical based instrumentation system (15L)

Fundamentals of medical Instruments: Role of Technology in medicine, Development in biomedical insterumentation medical devices.

Bioelectric signal: The origin of Biopotentials, measurement of Biopotentials, Electrical activity of excited cells, The concept of electrical impedance, impedance bridge circuits. Resting and Action Potential. Concept of ECG, EEG & EMG, Sensors requirement.

Medical Imaging: X rays, MRI, Ultrasonography.

References:

1. Measurement Systems, Applications and Design, Ernest O. Doeblin and Dhanesh N. Manik, 5th Edition, Tata McGraw Hill.
2. A Course in Electrical and Electronic Measurements and Instrumentation By A.K.Sawhney, Dhanpat Rai & Co.
3. Modern Electronic Instrumentation and Measurements Techniques, Cooper and Helfrick, PHI.
4. Biomedical instrumentation and measurement, R.Natrajani.
5. Biomedical Instrumemtation, R.S.Khandpur, 3rd edition.

Course Outcome	Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	2	-	-	-	-	-
CO2	2	1	2	1	1	-	-	-	-
CO3	3	2	2	3	3	2	-	2	3
CO4	3	2	2	3	2	3	-	2	3
CO5	2	2	3	3	2	2	-	3	2
CO6	3	2	2	2	2	1	-	-	2
CO7	2	3	2	2	1	2	-	-	1

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Students will able to demonstrate use instruments for measurement techniques precisely and use for various parameter measurements.

CO2: Students will develop deep understanding of instrument characteristics, handling and reducing error in instruments.

CO3,4: Students will master in demonstrate the use of sensors, transducers, actuators and it applications.

CO5: Students will develop knowledge to demonstrate the interfacing of sensor to develop system for dedicated applications.

CO6,7: Students will demonstrate the use of modern technology in biomedical applications.

PO2: Critical Thinking and Problem Solving

CO1,2: Students will apply their knowledge for selecting instrument for reducing error, good performance.

CO3,4,5: Students will think to develop specific instrument using sensor, transducer and actuators for dedicated application for solving complex problem.

CO6,7: Students will increase thinking ability to develop experimental skill to design electronics system for biomedical applications.

PO3: Social competence

CO1 to 6: Students will able to use various instruments, sensors and transducers for industrial, agriculture, medical, automobile or any other relevant application.

CO7: Student will apply the idea to exhibit the hardware design for medical field solve real-world problems.

PO4: Research-related skills and Scientific temper

CO2,3,4: Student develop their ability to think need of sensor and transducers and design necessary circuit.

CO1,5: Students will able to use scientific instruments for result analysis and standardisation.

CO6,7: Students apply their knowledge for biomedical application.

PO5: Trans-disciplinary knowledge

CO3,5: Student will use their knowledge for designing electronic system for solving practical problems in physics, chemistry, botany and other relevant subject.

CO6,7: It is useful for development of electronic system for biomedical application.

PO6: Personal and professional competence

CO3-7: Students to develop their ability to work independently or as a team to solve real-world problems.
Students develop their skills for starting own start-up in electronics design.
Students use their knowledge to develop suitable solution for interdisciplinary field.

PO8: Environment and Sustainability

CO3-5: Student will think to develop system for weather monitoring system which helps various applications, automation system for agriculture, automobile industry and energy conservation.

PO9: Self-directed and Life-long learning

CO3-7: Student will think the technical solution for real-world problems and start-up in electronics design for various applications. It is lifelong learning due to technology.

CBCS Syllabus as per NEP 2020 for M.Sc. I
(2023 Pattern)

Name of the Programme : M.Sc.Electronics

Programme Code : **PSELE**

Class : M.Sc. I

Semester : II

Course Type : Elective (Theory)

Course Code : ELE-562(B)-MJE

Course Title : Foundation of Semiconductor Devices.

No. of Credits : 04

No. of Teaching Hours : 60

Course Objectives:

1. To introduce crystal structure with reference to semiconductors
2. To introduce quantum and statistical mechanics
3. To provide students with a basic understanding of semiconductor materials and their properties, including concepts like energy bands, charge carriers, and doping.
4. Operating principles of modern semiconductor devices
5. To understand the theory and characteristics of semiconductor devices.
6. Determine the band structure of semiconductors when supplied with basic materials properties and applying their knowledge of quantum mechanics.
7. To understand the optical devices.

Course Outcomes:

By the end of the course, students will be able to:

CO1. Understand the concept of Quantum and statistical mechanics.
CO2. Students able to understand semiconductor fundamentals, including concepts related to energy bands, charge carriers, and crystal structures.
CO3. Students should be able to explain the operating principles of key semiconductor devices, such as diodes, bipolar junction transistors, and field-effect transistors.
CO4. Students should understand the basic processes involved in semiconductor device.
CO5. Understand the characteristics of semiconductor devices.
CO6. Students should be familiar with the various applications of diode, transistor and FETs
CO7. Understand the function of solar cell.

Topics and Learning Points

Unit-1: Theory of solids, quantum and statistical mechanics (15L)

Crystal structure of solids: types of solids, Semiconductor materials, basics of crystallography, Space lattice, unit cell, Crystal structures, atomic bonding, Miller indices, imperfections and impurities in solids, methods for semiconductor crystal growth.

Unit 2: Introduction to Quantum and statistical Mechanics (15L)

Quantum Theory of solids: Principles of quantum mechanics, Schrodinger wave equation and Applications of Schrodinger’s wave equation for bound state potential problems, Allowed & forbidden energy bands, electrical conduction in solids. Statistical mechanics: Statistical laws, Fermi-Dirac probability function, the distribution function and the Fermi energy.

Unit-3: Physics of semiconductors (15L)

Semiconductor in equilibrium: Dopant atoms and energy levels, extrinsic semiconductors, Statistics of donors and acceptors, charge neutrality, position of Fermi energy level. Carrier transport phenomena: charge, effective mass, drift current density, conductivity, carrier diffusion, graded impurity distribution, Hall effect. Non-equilibrium excess carriers in semiconductors: Carrier generation & recombination characteristics of excess carriers, quasi-Fermi energy levels, excess carrier lifetime, surface effects.

Unit-3: Basics of Semiconductor Devices (15L)

Diode: Fabrication process, Junction terminologies of PN junction diode, junction capacitance C-V characteristics, Qualitative and Quantitative analysis, diode equation, Reverse-bias breakdown, Transient response, Poisson’s equation BJT: Fabrication process, Terminology, electrostatics and performance parameters, Eber-Moll model, Two port model, hybrid – pi model, Modern BJT structures – polysilicon emitter BJT, Hetero junction bipolar transistor(HBT)FETs: JFET and MESFET - Junction terminologies, characteristics MOSFET: Fundamentals, Capacitance- voltage characteristics, I-V characteristics, Special semiconductor devices-Optical devices, Solar cells, Photodetectors.

References/Books:

1.Semiconductor Physics and Devices Basic Principles, Donald A. Neamen, TMH, 3rdEdition(2003)
2.Semiconductor Device fundamentals, Robert F. Pierret, PearsonEducation
3.Solid State Electronics Devices, Streetman, PHI, 5th Edition,(2006)
4.Principles of Electronic materials &dev, S.O. Kasap,Mcgraw Higher Ed Publication
5.Solid State Physics, Dekkar,Mcgraw Higher Ed publication
6.Introduction to Solid State Physics, C.Kittle,Wiley publication

Course Outcome	Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	2	-	1	-	-	-	-	-
CO2	1	3	-	2	-	1	-	-	-
CO3	2	2	2	2	-	-	-	-	-
CO4	3	1	-	2	-	2	-	-	-
CO5	-	-	-	1	-	-	-	-	-
CO6	2	2	-	3	-	2	-	-	1
CO7	3	2	-	2	-	2	-	1	-

Justification for the mapping

PO1: Disciplinary Knowledge

CO1: Understanding the concept of Quantum and statistical mechanics contributes to disciplinary knowledge.
CO2: Understanding semiconductor fundamentals aligns with disciplinary knowledge.
CO3: Explaining the operating principles of semiconductor devices contributes to disciplinary knowledge
CO4,5: Understanding the basic processes involved in semiconductor devices enhances disciplinary knowledge.
CO6: Being familiar with the various applications of semiconductor devices contributes to disciplinary knowledge
CO7: Understanding the function of solar cells adds to disciplinary knowledge

PO2: Critical Thinking and Problem Solving

CO1: Understanding quantum and statistical mechanics requires critical thinking
CO2: Understanding semiconductor fundamentals involves critical thinking.
CO3: Explaining operating principles of semiconductor devices requires critical thinking.
CO4,5: Understanding basic processes in semiconductor devices involves problem-solving skills.
CO6: Being familiar with various applications involves critical thinking.
CO7: Understanding the function of solar cells requires critical thinking.

PO3: Social competence

CO3: The ability to explain operating principles enhances social competence

PO4: Research-related skills and Scientific temper

CO1: Understanding quantum and statistical mechanics involves scientific temper

CO2: Understanding semiconductor fundamentals requires research-related skills and scientific temper
CO3: Explaining operating principles of semiconductor devices involves scientific temper.
CO4: Understanding basic processes in semiconductor devices involves research-related skills.
CO5: Understanding characteristics of semiconductor devices involves scientific temper.
CO6: Use of semiconducting devices for research applications.
CO7: Contribute to research-related skills to increasing solar efficiency

PO6: Personal and professional competence

CO2: Understanding semiconductor fundamentals contributes to personal and professional competence.
CO4: Understanding basic processes in semiconductor devices contributes to personal and professional competence.
CO6: Being familiar with various applications contributes to personal and professional competence.
CO7: Understanding the function of solar cells contributes to personal and professional competence.

PO8: Environment and Sustainability

CO7: Understanding characteristics of solar cell can be related to environmental aspects.

PO9: Self-directed and Life-long learning

CO6: Being familiar with various applications encourages self-directed and life-long learning.