# Anekant Education Society’s
# Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
## Autonomous

**Course Structure & Credit Distribution for**
**F. Y. B. Sc. Electronic Science (Sem. II)**
**(2022-23)**

| Semester | Paper Code | Title of Paper | No. of Credits |
|---|---|---|---|
| II | USEL121 | Semiconductor Devices & Circuits | 2 |
| | USEL122 | Digital Electronic Circuits | 2 |
| | USEL123 | Electronics Practical’s | 2 |

## SYLLABUS (CBCS) FOR F. Y. B. Sc. (Electronic Science)
## (w.e.f. June, 2022)

**Class : F.Y. B. Sc. (Electronic Science) (Semester- II)**
**Paper Code : USEL 121**
**Title of Paper : Semiconductor Devices & Circuits**
**Paper : I**
**Credit : 2 No. of lectures: 36**

**Course Objectives**:

1. To study characteristic features of semiconductor devices.
2. To study characteristic features of diode, BJT, FET, UJT.
3. To learn applications of BJT, FET and UJT.
4. To understand basics and applications of operational amplifiers.
5. To understand analysis and design of simple diode circuits.
6. To give understand of various type of amplifier circuits.
7. To develop skill to build digital circuits.

**Course Outcome:**

After completion of this course student is able to

CO1 - Demonstrate and analyze the behavior of semiconductor devices
CO2 - To get an insight about the operation of B JT, FET, UJT in order to design the basic circuits
CO3- Understand the basic material and properties of semiconductors
CO4 - Explore constructional features and I-V characteristics of basic semiconductor devices diode, Transistors
CO5 - Apply basic concepts of P-N junction in developing simple application circuits
CO6 - Attain knowledge of various amplifiers and their comparison
CO7 - Understand the operational amplifier and their application

**Unit 1: Basic of Semiconductor (04L)**

Introduction to semiconductor materials, Energy level diagram, Intrinsic & Extrinsic semiconductors, n-type semiconductor, p-type semiconductor.

**Unit 2: Semiconductor Diodes & Circuits (10L)**

Study of semiconductor active components (w.r.t. symbol, working principle, characteristics, parameters, specifications, applications): P-N junction diode, Zener diode, Varactor diode, Light Emitting Diode(LED),Photo diode, Optocoupler, Rectifiers, clipper and clamper circuits.

**Unit-3:Bipolar Junction Transistor and its applications (12L)**

Bipolar Junction Transistor (symbol, types, construction, working principle, I-Vcharacteristics, parameters, specifications),concept of amplifier, transistor as a amplifier, configurations of transistors (CC,CE& CB), Biasing circuit (Potential divider only), DC load line (CE), Q point, ,concept of class A, B, C and class AB amplifiers, transistor as a switch.

**Unit-4: UJT and FETs (10L)**

Uni-Junction Transistor (UJT), Junction Field Effect Transitor (JFET), Metal Oxide Semiconductor Field Effect Transistor (MOSFET) (Symbol, construction, working principle, I-V characteristics), JFET as voltage variable resistor.

**Reference Books:**
1. Basic Electronics: Bernard Grob, McGraw Hill Publication, 8th Revised Edition,2010
2. Electronic Principles: Albert Malvino, David J Bates, McGraw Hill 7th Edition. 2012
3. Modern Digital Electronics: R.P. Jain, Mcgraw Hill

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | **3** | **-** | **-** | **-** | **3** | **-** | **-** | **3** |
| **CO2** | **2** | **3** | **2** | **-** | **-** | **2** | **-** | **-** | **2** |
| **CO3** | **3** | **3** | **2** | **-** | **1** | **3** | **-** | **1** | **3** |
| **CO4** | **2** | **2** | **1** | **-** | **-** | **2** | **-** | **-** | **2** |
| **CO5** | 3 | **3** | **-** | **-** | **-** | **3** | **-** | **-** | **3** |
| **CO6** | **3** | **3** | **-** | **-** | **-** | **2** | **-** | **-** | **3** |
| **CO7** | **2** | **2** | **-** | **1** | **-** | **2** | **-** | **-** | **2** |

## Justification of Mapping

**PO1-Disciplinary Knowledge:**

CO1- Demonstrating and analyzing the behavior of semiconductor devices directly aligns with the comprehensive knowledge of the discipline and the theoretical understanding required in the graduate program.
CO2- Gaining insight into the operation of BJT, FET, UJT for designing basic circuits is a practical application of the theoretical understanding within the graduate program.
CO3- Understanding the basic material and properties of semiconductors is foundational knowledge for comprehending the behavior and characteristics of semiconductor devices.
CO4- Exploring the constructional features and I-V characteristics of basic semiconductor devices (diodes, transistors) directly aligns with the graduate program's emphasis on theoretical and practical understanding.
CO5- Applying basic concepts of P-N junction in developing simple application circuits demonstrates the integration of theoretical knowledge into practical applications within the discipline.
CO6- Attaining knowledge of various amplifiers and comparing them aligns with the graduate program's objective of comprehensive knowledge and theoretical understanding.
CO7- Understanding the operational amplifier and its applications directly relates to the theoretical and practical aspects of the graduate program.

**PO2-Critical Thinking and Problem solving:**

CO1- Analyzing the behavior of semiconductor devices requires critical thinking and problem-solving skills to understand and address complex electronic characteristics.
CO2- Designing basic circuits based on the operation of BJT, FET, UJT involves critical thinking and problem-solving, demonstrating the application of theoretical knowledge in practical situations.
CO3- Understanding the basic material and properties of semiconductors is crucial for problem-solving in the design and analysis of semiconductor devices.
CO4- Exploring constructional features and I-V characteristics of basic semiconductor devices (diodes, transistors) involves critical thinking in addressing circuit design challenges and troubleshooting.
CO5- Applying basic concepts of P-N junction in developing simple application circuits requires problem-solving skills to create effective solutions.
CO6- Comparing various amplifiers involves critical thinking to evaluate their characteristics and choose the most suitable one for a given application.
CO7- Understanding the operational amplifier and its applications demonstrates critical thinking in solving problems related to amplifier configurations and applications.

**PO3-Social competence:**

CO2- Gaining insight into the operation of BJT, FET, UJT for designing basic circuits may require collaborative work, contributing to group interactions and social competence.

CO3- Understanding the basic material and properties of semiconductors may have limited direct impact on social competence but could indirectly support effective communication within a team.

CO4- Exploring constructional features and I-V characteristics of basic semiconductor devices may involve collaboration and communication, enhancing social competence.

**PO4-Research-related skills and Scientific temper:**

CO7- Understanding the operational amplifier and its applications involves practical application and experimentation, fostering research-related skills and a scientific temper.

**PO5-Trans-disciplinary knowledge:**

CO3- Understanding the basic material and properties of semiconductors draws on principles from materials science and electronics, contributing to a trans-disciplinary understanding.

**PO6-Personal and professional competence:**

CO1- Demonstrating and analyzing the behavior of semiconductor devices involves teamwork and collaboration, contributing to personal and professional competence.

CO2- Gaining insight into the operation of BJT, FET, UJT for designing basic circuits may require collaboration within a team, fostering personal and professional competence.

CO3- Understanding the basic material and properties of semiconductors may involve collaborative efforts in a laboratory setting, contributing to personal and professional competence.

CO4- Exploring constructional features and I-V characteristics of basic semiconductor devices involves teamwork and collaboration, enhancing personal and professional competence.

CO5- Applying basic concepts of P-N junction in developing simple application circuits may involve collaborative efforts within a team, contributing to personal and professional competence.

CO6- Attaining knowledge of various amplifiers and their comparison may require collaborative discussions, fostering personal and professional competence.

CO7- Understanding the operational amplifier and its applications may involve teamwork and collaboration, contributing to personal and professional competence.

**PO8-Environment and Sustainability:**

CO3- Understanding the basic material and properties of semiconductors may have implications for sustainable material use in electronic components.

**PO9- Self-directed and Life-long learning:**

CO1- Demonstrating and analyzing the behavior of semiconductor devices encourages independent learning through research and experimentation, fostering a self-directed approach.

CO2- Gaining insight into the operation of BJT, FET, UJT for designing basic circuits promotes self-directed learning and the acquisition of knowledge necessary for lifelong learning.

CO3- Understanding the basic material and properties of semiconductors requires continuous learning to stay updated on advancements in materials science and semiconductor technology.

CO4- Exploring constructional features and I-V characteristics of basic semiconductor devices encourages ongoing learning and adaptation to new developments in device design.

CO5- Applying basic concepts of P-N junction in developing simple application circuits necessitates continuous learning to stay abreast of evolving applications and technologies.

CO6- Attaining knowledge of various amplifiers and their comparison encourages ongoing learning in the dynamic field of amplifier technology.

CO7- Understanding the operational amplifier and its applications promotes lifelong learning by staying informed about new applications and advancements in operational amplifier technology.

**ANEKANT EDUCATION SOCIETY'S**

TULAJARAM CHATURCHAND COLLEGE of ARTS, SCIENCE AND COMMERCE, BARAMATI

**(AUTONOMOUS)**

**F.Y.B.Sc. ( Electronic Science )**

**SEMESTER II (2022 Pattern)**

**(2022-23)**

**Paper II : USEL 122 : Digital Electronic Circuits**

**( 2 Credits, 36 Lectures)**

## Course Objectives:

1. To get familiar with concepts of digital circuits.
2. To learn combinational circuits.
3. To learn sequential circuits.
4. To study different flip-flops.
5. To study different shift resisters.
6. To study logic families and IC technology.

## Course Outcome:

CO1- Analyze and design combinatorial circuits.
CO2- Analyze and design sequential circuits.
CO3- Realize combinational circuits and sequential circuits for given application.
CO4- Implement combinational logic circuits using programmable logic devices.
CO5- Recognizes different type of flip flop that are falling edges, rising edges and surface trigger.
CO6- Prepare logical symbol and truth tables of RS, JK and T flip-flop
CO7- Understand how logical problems can be solved by using multiplexer, demultiplexer, comparator.

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**UNIT 1: Combinational Circuits** **( 12 )**

Introduction, Types of Digital Circuits, Comparision, Multiplexer- 2:1 Multiplexer, 4:1 multiplexer, Applications. Demultipexer - 1 :2 Demultiplexer, 1:4 Demultiplexer, Applications. Encoders - Need, Types of Encoders - Decimal to BCD, Priority Encoder. Decoders - Need, Types of Decoders - BCD to 7 segment decoder. Types of 7 segment display - Common Anode, Common Cathode, IC 7447, IC 7448.

**UNIT 2 : Flip Flops** **( 12 )**

Introduction, Need of Sequential Circuits, types of Flip Flops - RSFF, Clocked RSFF, JKFF, DFF, TFF, Master Slave JKFF, Applications. Concept of Triggering levels - Positive Edge Triggering, Negative Edge Triggering. Positive Edge Triggered FFs, Negative Edge Triggered FFs, Timing Diagrams.

**UNIT 3 : Counters and Shift Registers** **( 12 )**

Counters : Introduction, Need of Counters, types of Counters : Asynchronous, Synchronous . Binary Counter, 4 bit binary counter, Up Counter, Down Counter, 3 bit Up-Down counter, timing diagrams, Modulus counter - IC 7490 as a decade counter.

Registers :Shift Registers, Left Shift, Right Shift. Type of Shift Registers - SISO, SIPO, PISO, PIPO, IC 7491A 8-bit Shift Register, Applications. Ring Counter, Universal Shift Register, Bidirectional Register. Introduction to Computers.

**References :**


1. Digital Electronics : Principles, Devices and Applications - Anil K. Maini (Wiley)
2. Digital Fundamentals - Floyd T.N. and Jain R.P. (Pearson Education)
3. Digital System Design - M. Morris Mano ( Pearson Education )
4. Digital Principles and Applications - Leach, Malvino, Saha ( TMH )


| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** |
|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | - | - | - | 1 | - | - | 3 |
| **CO2** | 3 | 3 | 2 | - | - | 2 | - | - | 2 |
| **CO3** | 3 | 3 | 1 | - | 1 | - | - | 1 | 3 |
| **CO4** | 2 | 2 | 1 | - | - | 1 | - | - | 2 |
| **CO5** | 3 | 2 | - | - | - | 3 | - | - | 3 |
| **CO6** | 2 | 3 | 2 | - | 1 | 2 | - | - | 3 |
| **CO7** | 3 | 2 | - | - | - | 2 | - | - | 2 |

## Justification of Mapping

**PO1-Disciplinary Knowledge:**

CO1- Combinatorial circuits form a fundamental aspect of the broader discipline, requiring a deep understanding of digital logic and logical operations, aligning with the comprehensive knowledge expected at the graduate level.

CO2 – Sequential circuits are an integral part of digital circuit design, and their analysis and design involve advanced concepts beyond combinatorial circuits, contributing significantly to the depth of understanding expected at the graduate level.

CO3- The ability to realize both combinational and sequential circuits for specific applications show cases a practical application of the theoretical knowledge acquired in the graduate program, aligning with the execution of strong theoretical and practical understanding.

CO4- While programmable logic devices are not exclusive to combinational circuits, the implementation of combinational logic circuits using these devices involves a degree of specialization, making it moderately related to the broader disciplinary knowledge.

CO5- Understanding various flip-flop types is relevant to sequential circuit design, contributing to the theoretical knowledge expected in the graduate program but not as directly tied to the broader disciplinary knowledge.

CO6- The preparation of logical symbols and truth tables for different flip-flop types demonstrates a strong theoretical understanding of these essential components in sequential circuits, aligning well with the expected graduate-level knowledge.

CO7- Solving logical problems using multiplexers, demultiplexers, and comparators requires a comprehensive understanding of their functionality, linking directly to the broader disciplinary knowledge and practical application in the given context.

**PO2- Critical Thinking and Problem solving:**

CO1- Analyzing and designing combinatorial circuits directly aligns with the critical thinking and problem-solving skills emphasized in PO2, requiring analysis and design in response to specific situations.

CO2- Analyzing and designing sequential circuits is closely tied to critical thinking and problem-solving, requiring the application of logical reasoning and problem-solving skills to design sequential circuits.

CO3- Realizing combinational and sequential circuits for given applications involves critical thinking and problem-solving skills, making it strongly related to the skills emphasized

CO4- Implementing combinational logic circuits using programmable logic devices requires problem-solving skills, making it strongly related to the critical thinking and problem-solving

CO5- Recognizing different types of flip-flops involves analysis and inference, contributing to a moderate relationship with critical thinking and problem-solving skills

CO6- Preparing logical symbols and truth tables of flip-flops involves analysis and interpretation, contributing to a moderate relationship with critical thinking and problem-solving skills

CO7- Understanding how logical problems can be solved by using multiplexers, demultiplexers, and comparators involves analysis and problem- solving, resulting in a moderate relationship with the skills.

**PO3 – Social competence:**

CO2- Analyzing and designing sequential circuits is more focused on technical aspects, with limited direct relevance to the behavioral skills needed for successful social adaptation and group work .

CO3- Realizing combinational and sequential circuits for given applications is primarily a technical skill, with limited direct relevance to the social competence

CO4- Implementing combinational logic circuits using programmable logic devices is a technical task and has limited direct relevance to the social competence

CO6- Preparing logical symbols and truth tables of flip-flops is primarily a technical skill, with limited direct relevance to the social competence.

**PO5- Trans-disciplinary Knowledge:**

CO3- Realizing combinational and sequential circuits for given applications is primarily a technical skill, with limited direct relevance to the integration of different disciplines.

CO6- Preparing logical symbols and truth tables of flip-flops is primarily a technical skill, with limited direct relevance to the integration of different disciplines.

**PO6-Personal and Professional competence:**

CO1- Analyzing and designing combinatorial circuits requires collaboration and interdisciplinary understanding, promoting personal and professional competence.

CO2- Analyzing and designing sequential circuits involves teamwork, meeting objectives, and adapting to diverse requirements, contributing to personal and professional competence.

CO4- Implementing combinational logic circuits using programmable logic devices involves teamwork and interdisciplinary work, contributing to personal and professional competence.

CO5- Recognizing different types of flip-flops involves self-motivation and adaptability skills, contributing to personal competence.

CO6- Preparing logical symbols and truth tables of RS, JK, and T flip-flops involves interpersonal relationships and a commitment to professional ethics, enhancing personal and professional competence.

CO7- Understanding how logical problems can be solved by using multiplexer, demultiplexer, comparator involves collaboration and interdisciplinary understanding, contributing to personal and professional competence.

**PO8- Environment and Sustainability:**

CO3- Realizing combinational and sequential circuits for given applications may not have immediate ties to environmental sustainability but could indirectly contribute through efficient circuit implementations.

**PO9- Self-directed and Lifelong learning:**

CO1- Analyzing and designing combinatorial circuits encourages independent learning through research and application, fostering a self-directed approach.

CO2- Analyzing and designing sequential circuits necessitates continuous learning and adaptation to evolving technologies, promoting a self-directed and lifelong learning approach.

CO3- Realizing combinational and sequential circuits for given applications requires ongoing learning to stay updated on advancements, contributing to a self-directed and lifelong learning attitude.

CO4- Implementing combinational logic circuits using programmable logic devices involves continuous learning and adaptation to new devices and technologies, supporting a self-directed approach.

CO5- Recognizing different types of flip-flops requires ongoing learning and adaptation to changes in technology, fostering a self-directed and lifelong learning mindset.

CO6- Preparing logical symbols and truth tables of RS, JK, and T flip-flops involves continuous learning, contributing to a self-directed and lifelong learning approach.

CO7- Understanding how logical problems can be solved by using multiplexer, demultiplexer, comparator requires continuous learning, supporting a self-directed and lifelong learning attitude.

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**SEMESTER II ( 2022 Pattern)**

**Paper III : USEL 123 : Electronics Practical's**

**(2022-23)**

**( 2 Credits )**

**Course Objectives**:

1. To teach students how to draw different symbols and circuit diagrams
2. To develop skill of circuit connections
3. To familiarize the student with different components and devices used in the laboratory and the device manuals
4. To familiarize students with laboratory instruments like Ammeter, voltmeter, DMM, Signal Generator, Function Generator, CRO and tools like cutter, stripper etc.
5. To train them to design and analyze the circuits for specific purpose
6. To teach the students how to analyze the results and calculate performance parameters
7. To motivate them to work on different mini projects

**Course Outcome:**

After completion of this course student will be able

CO1. To identify different components and devices as well as their types
CO2. To understand basic parameters associated with each device
CO3. To know operation of different instruments used in the laboratory
CO4. To connect circuit and do required performance analysis
CO5. To compare simulated and actual results of given particular experiment.
CO6. Capability to develop experimental skill analyzing the results and interpret data.
CO7. Develop hobby projects.

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**Group A : Activities ( Any one )**

Perform any one of the following activities with proper documentation.

a) Hobby Projects

b) Internet Browsing

c) Industrial Visit / Live Work Experience

d) Market Survey of Electronic Systems

e) Study tour and its Report Writing.

f) IC Testing

**Group B : Analog Electronics ( Any Four )**

1. Study of forward and Reverse biased characteristics of PN Junction Diode
2. Study of breakdown characteristics and voltage regulation action of Zener diode.
3. Study of output characteristics of Bipolar Junction Transistor in CE mode.
4. Study of output and transfer characteristics of JFET/MOSFET
5. Study of I-V characteristics of UJT and Demonstration of UJT based relaxation oscillator.
6. Study of low voltage Half-wave, Full-wave and Bridge rectifier circuits.
7. Study of amplification action of BJT.
8. Study of clipping circuit (Bias).
9. Study of opto-coupler.
10. Study of angular response of LED.
11. Study of transistor as switch.

**Group C : Digital Electronics ( Any Four )**

1. Build and Test 8 : 1 MUX/ 1:8 DeMUX using gates.
2. Build and Test Keyboard Encoder.
3. Build and Test Diode Matrix ROM.
4. Study of Flip Flops ( RS, JK, D ,T types).
5. Study of Decade Counter.
6. Study of Up/ Down Counter.
7. Study of 4 bit Shift Register.
8. Study of Decoders

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | - | 3 | 3 | - | - | 3 |
| **CO2** | 3 | 3 | 2` | - | 2 | 2 | - | - | 2 |
| **CO3** | 3 | 3 | 2 | - | 1 | 2 | - | 1 | 3 |
| **CO4** | 2 | 2 | 2 | - | 3 | 3 | - | - | 2 |
| **CO5** | 3 | 2 | - | - | 2 | 3 | - | - | 3 |
| **CO6** | 3 | 3 | - | - | 2 | 2 | - | - | 3 |
| **CO7** | 3 | 2 | 1 | - | 2 | 2 | - | - | 1 |

## Justification of Mapping

**PO1-Disciplinary Knowledge:**

CO1- Identifying different components and devices aligns with comprehensive knowledge in the graduate program, demonstrating theoretical and practical understanding.

CO2- Understanding basic parameters associated with each device contributes to strong theoretical knowledge in the graduate program.

CO3- Knowing the operation of different instruments used in the laboratory supports practical understanding within the graduate program.
CO4- Connecting circuits and performing required performance analysis demonstrates a strong blend of theoretical and practical skills in the graduate program.
CO5- Comparing simulated and actual results of experiments aligns with the practical application of theoretical knowledge in the graduate program.
CO6- Developing experimental skills, analyzing results, and interpreting data showcase a comprehensive understanding of both theoretical and practical aspects in the graduate program.
CO7- Developing hobby projects involves practical application and demonstrates a degree of theoretical understanding, contributing to the overall knowledge in the graduate program.

**PO2- Critical Thinking and Problem solving:**

CO1- Identifying different components and devices requires critical analysis and observation, contributing to critical thinking and problem-solving skills.
CO2- Understanding basic parameters associated with each device involves analysis and inference, fostering critical thinking in problem-solving scenarios.
CO3- Knowing the operation of different instruments used in the laboratory requires problem-solving skills and interpretation of data, aligning with critical thinking.
CO4- Connecting circuits and performing required performance analysis involves problem-solving and critical analysis of circuit behavior.
CO5- Comparing simulated and actual results of experiments necessitates critical analysis and problem-solving to reconcile differences and draw meaningful conclusions.
CO6- Developing experimental skills, analyzing results, and interpreting data require critical thinking and problem-solving capabilities.
CO7- Developing hobby projects involves critical thinking and problem-solving in the design and implementation of projects.

**PO3-Social competence:**

CO1- Identifying different components and devices may involve collaboration, enhancing social competence in group work.
CO2- Understanding basic parameters associated with each device may require effective communication of ideas, contributing to social competence.
CO3- Knowing the operation of different instruments used in the laboratory involves collaboration and effective communication, fostering social competence in group settings.
CO4- Connecting circuits and performing required performance analysis may involve teamwork, enhancing social competence in collaborative environments.
CO7- Developing hobby projects involves effective communication of thoughts and ideas, contributing to social competence.

**PO5-Trans-disciplinary knowledge:**

**CO1-** Identifying different components and devices involves integrating knowledge from various disciplines, contributing to a trans-disciplinary approach.
CO2- Understanding basic parameters associated with each device requires the integration of knowledge from different disciplines, supporting a trans-disciplinary perspective.
CO3- Knowing the operation of different instruments used in the laboratory involves integrating knowledge from various disciplines, fostering a trans-disciplinary understanding.
CO4- Connecting circuits and performing required performance analysis integrates knowledge from electronics and other disciplines, supporting a trans-disciplinary approach.
CO5- Comparing simulated and actual results of experiments involves integrating knowledge from simulations and practical experimentation, contributing to a trans-disciplinary understanding.
CO6- Developing experimental skills, analyzing results, and interpreting data requires the integration of knowledge from various disciplines, supporting a trans-disciplinary approach.
CO7- Developing hobby projects involves integrating knowledge from different domains, contributing to a trans-disciplinary perspective.

**PO6-Personal and professional competence:**

CO1- Identifying different components and devices involves teamwork, contributing to personal and professional competence.

CO2- Understanding basic parameters associated with each device requires self-motivation and adaptability, enhancing personal and professional competence.
CO3- Knowing the operation of different instruments used in the laboratory involves collaboration and teamwork, fostering personal and professional competence.
CO4- Connecting circuits and performing required performance analysis requires interpersonal relationships and collaboration, contributing to personal and professional competence.
CO5- Comparing simulated and actual results of experiments involves teamwork and collaboration, enhancing personal and professional competence.
CO6- Developing experimental skills, analyzing results, and interpreting data requires self-motivation and adaptability, contributing to personal and professional competence.
CO7- Developing hobby projects involves collaboration and interpersonal relationships, fostering personal and professional competence.

**PO8-Environment and Sustainability:**

CO3- Knowing the operation of different instruments used in the laboratory may have limited direct ties to environmental sustainability but could indirectly contribute through efficient laboratory practices.

**PO9- Self-directed and Life-long learning:**

CO1- Identifying different components and devices encourages self-directed learning and staying updated on technological changes.
CO2- Understanding basic parameters associated with each device promotes continuous learning and adaptability in response to technological changes.
CO3- Knowing the operation of different instruments used in the laboratory fosters a self-directed approach to learning and staying abreast of technological advancements.
CO4- Connecting circuits and performing required performance analysis requires ongoing learning to adapt to changes in technology, supporting a self-directed and lifelong learning attitude.
CO5- Comparing simulated and actual results of experiments necessitates continuous learning and adaptability to evolving technologies.
CO6- Developing experimental skills, analyzing results, and interpreting data involve ongoing learning and adaptability, fostering a self-directed and lifelong learning approach.
CO7- Developing hobby projects encourages continuous learning and self-motivation, aligning with the goal of lifelong learning.