DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, CHHATRAPATI SAMBHAJINAGAR.

NAAC- 'A $^{+}$' Grade

CIRCULAR NO.SU/ AEDP/ Deptt./78/2026

It is hereby inform to all concerned that, on the recommended by the Dean, ***Academic Council at its meeting held on 02nd June 2026 has accepted*** the following Subject wise Curriculum as per ***"Apprenticeship Embedded Degree Programme (AEDP)"*** run at University Department, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapathi Sambhajinagar as appended herewith.

Sr.No.	Name of the Courses	Department	Faculty	Semester
1.	B.Sc.Electronics (Honours) Industrial Electronics Minor in Sensor Technology /Energy Storage Devices	Electronics	Faculty of Science & Technology	IIIrd & IVth
2.	B.Sc.Data Science	Computer Science & IT		
3.	B.C.A. (Honors)	Management Science	Faculty of Commerce & Management Science	
4.	B.A.Psychology	Psychology	Faculty of Humanities	

This is effective from the Academic Year 2026-27 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus, ★
Chhatrapati Sambhajinagar. ★
Ref.No.SS/AC/I.No.04/2026/4498-106 ★
Date:-05/06/2026 ★

★★★★★

Deputy Registrar
Syllabus Section

Copy forwarded with compliments to :-

1] **The Head of the Department, CS & IT, Electronics & Management Science, Psychology.**
2] The Deputy Registrar, Post Graduate Section,
Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
3] **The Director, University Network & Information Centre, UNIC, with a <u>request to upload this Circular on University Website.</u>**

Copy to :-

1] The Director, Board of Examinations & Evaluation
2] The Section Officer,[B.Sc./B.Com. BA/Unit]
3] The Programmer [Computer Unit-1 & 2]
4] The In-charge, [E-Suvidha Kendra],
Rajarshi Shahu Maharaj Pariksha Bhavan,
Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

JD*05062026/- -=**=-

Dr. Babasaheb Ambedkar Marathwada University
Chhatrapati Sambhajinagar- 431004

Revised Course Structure (All four year)

And

Syllabus (Second year)

For

B.Sc. Electronics (Honours)

(AS PER NEP-2020)

Subject (Major): Industrial Electronics

Minor in

Sensor Technology/Energy Storage Devices

For

Apprenticeship Embedded/Research Degree Programs

(AERDPs)

Effective from 2025-26

B.Bhaskar 29/05/2026

Professor Bhaskar Sathe,
Dean,
Faculty of Science & Technology,
Dr.Babasaheb Ambedkar
Marathwada University,
Chhatrapati Sambhajinagar

20/4/26
Head, Dept of Electronics

Head
Department of Electronics
Dr.Babasaheb Ambedkar Marathwada University,
Chhatrapati Sambhajinagar - 431004

Preface

Forging Future-Ready Scientists / Engineers: The 4-Year Apprenticeship-Embedded / Research Degree Programme (AERDP), B.Sc. Electronics (Hons), with Major in Industrial Electronics and Minor in Sensor Technology / Energy Storage Devices.

We stand at a defining moment in the evolution of higher education in India, as the **National Education Policy 2020 (NEP 2020)** charts a bold and transformative vision. Rooted in principles of flexibility, multidisciplinary, equity, and excellence, NEP 2020 heralds a shift toward learner-cantered, skills-integrated education. The **Bachelor of Science (Honours) 4-Year Degree Program**, with embedded apprenticeship and research opportunities, is a direct response to this visionary mandate.

This pioneering program has been **carefully designed in consultation with the Electronics Industries** to ensure alignment with current and emerging industry needs. The syllabus integrates **academic foundations with industry-relevant competencies**, offering students a robust scientific education alongside valuable hands-on experience. Furthermore, the program will be **implemented in active collaboration with Electronics Industries**, providing access to skill training resources, apprenticeship networks, and certification pathways recognized across the electronics and allied sectors.

The curriculum blends **academic rigor with practical relevance**, preparing students to meet contemporary scientific, technological, and societal challenges. True to the spirit of NEP 2020, it emphasizes **multidisciplinary and interdisciplinary learning**, critical thinking, innovation, and ethical reasoning. Students are encouraged to break out of traditional disciplinary silos and engage in learning that is dynamic, applied, and globally informed.

A key highlight of this program is its **experiential fourth year**, which offers students **two distinct pathways**:

1. **Industry Apprenticeship Track: A One-year (during 4th year) apprenticeship in a relevant industry**, enabling students to gain hands-on experience, workplace skills, and industry insights under real-world conditions—facilitated through NAPS (National Apprenticeship Promotion Scheme) apprenticeship frameworks and partnerships (Apart from a 6-months mandatory **apprenticeship in a relevant industry during 3rd year).**

2. **Research Track in Sensor Technology**: A one-year **specialized research training program** in **sensor technology**, providing students with the opportunity to work on cutting-edge research problems under the guidance of experts in the field (Apart from a 6-months mandatory **apprenticeship in a relevant industry during 3rd year).**

This flexible structure empowers students to tailor their learning journey—whether their goal is professional employment or advanced research in high-impact areas such as sensing systems, electronics, and sustainable technologies.

The program also upholds NEP 2020's unwavering commitment to **inclusivity, equity, and excellence in education**. It fosters a vibrant and supportive environment where students from diverse backgrounds are encouraged to thrive. Ethical awareness, environmental responsibility, and social impact are woven throughout the curriculum, shaping graduates into **responsible citizens and compassionate leaders**.

By promoting **a culture of inquiry, practical engagement, and lifelong learning**, this program prepares students not only to excel in their chosen domains but also to contribute meaningfully to the advancement of knowledge, innovation, and nation-building.

As we align higher education with national priorities and global trends, this **4-Year B.Sc. Electronics (Hons) Program** stands as a model of future-ready, skill-integrated science education. Guided by the principles of NEP 2020, we are confident that this initiative will nurture a new generation of scientists, innovators, and changemakers—equipped to shape a more resilient and sustainable future.

Programme Educational Objectives (PEOs)

B.Sc. Electronics (Hons), with Major in Industrial Electronics and Minor in Sensor Technology / Energy Storage Devices (Apprenticeship-Embedded / Research Track).

In alignment with the **National Education Policy 2020** and developed in consultation with the **Electronics Industries**, the Programme Educational Objectives (PEOs) for the B.Sc. (Hons) in Industrial Electronics are designed to ensure that graduates are equipped with academic excellence, industry readiness, and research competence. These objectives are as follows:

1. **Mastery of Industrial Electronics and Applied Sciences**

   Graduates will demonstrate a strong foundation in core principles, systems, and technologies related to industrial electronics. They will be able to apply theoretical and practical knowledge to analyze, design, and troubleshoot electronic systems across industrial applications.

2. **Industry and Research Integration**

   Graduates will gain significant hands-on experience through a **structured fourth-year apprenticeship in industry or specialized research training in sensor technology**. This dual-track model ensures they develop relevant professional competencies, research skills, and adaptability to thrive in either industrial or academic environments.

3. **Interdisciplinary and Skill-Based Proficiency**

   Graduates will integrate concepts from electronics, instrumentation, computing, and emerging technologies to solve real-world problems. Through collaboration with **Electronics industries,** they will acquire domain-specific skills and certifications aligned with national skill development goals.

4. **Critical Thinking, Innovation, and Problem-Solving**

   Graduates will be trained to think critically, use analytical tools, interpret data, and engage in design thinking. They will apply scientific reasoning to drive innovation in industrial systems, automation, and sensor-based technologies.

5. **Leadership, Ethics, and Professionalism**

   Graduates will demonstrate leadership, entrepreneurship, and teamwork skills. They will uphold ethical practices, professional responsibility, and environmental sustainability while addressing industry and societal needs.

6. **Global Outlook and Lifelong Learning**

   Graduates will exhibit global awareness, cultural sensitivity, and the ability to work in diverse environments. They will be prepared for continuous learning, higher studies, or evolving careers in industrial electronics, automation, embedded systems, and sensor technologies.

Programme Outcomes (POs)

B.Sc. Electronics (Hons), with Major in Industrial Electronics and Minor in Sensor Technology / Energy Storage Devices (Apprenticeship-Embedded / Research Track).

This innovative four-year degree program integrates strong academic foundations with hands-on industry training and specialized research exposure, preparing students to meet the needs of rapidly evolving electronics and sensor-based industries. The following Programme Outcomes reflect the core vision of **NEP 2020** and the structure of this **Electronics Industries -linked** program:

- **PO1. Scientific and Societal Responsibility**

  Apply domain knowledge in **industrial electronics and sensor technology** to analyze and address complex real-world problems while being mindful of ethical, societal, economic, and environmental implications in both local and global contexts.

- **PO2. Environmental Sustainability**

  Demonstrate understanding of sustainable practices in electronics manufacturing, embedded systems, and sensor applications, and advocate for solutions that promote ecological balance and responsible resource use.

- **PO3. Ethics and Professional Integrity**

  Integrate ethical reasoning into scientific inquiry and industrial practice; uphold professional ethics, intellectual honesty, and a commitment to social responsibility in technology-driven environments.

- **PO4. Teamwork and Leadership in Multidisciplinary Settings**

  Work effectively as an individual, in teams, and in leadership roles within **multidisciplinary projects** involving electronics, instrumentation, and sensor systems; demonstrate collaborative skills in both **industrial apprenticeships and research laboratories**.

- **PO5. Communication and Documentation Skills**

  Communicate complex scientific and technical ideas clearly and effectively through oral presentations, technical writing, and design documentation. Engage with industry professionals, researchers, and society at large to disseminate knowledge.

- **PO6. Innovation, Project Management, and Entrepreneurship**

  Demonstrate the ability to plan, execute, and manage **industry-applied or research-based projects** in electronics and sensor technology, incorporating basic principles of innovation, entrepreneurship, time management, and financial planning.

- **PO7. Lifelong Learning and Technological Adaptability**

  Exhibit readiness for **lifelong learning** and continuous professional development in a technology-driven world. Adapt to emerging tools, platforms, and research trends in electronics, automation, and smart sensing systems.

  These outcomes empower graduates to be **technically competent, ethically grounded, and professionally versatile**, whether they choose to pursue careers in industry, research, entrepreneurship, or higher studies.

Programme Specific Outcomes (PSOs)

B.Sc. Electronics (Hons), with Major in Industrial Electronics and Minor in Sensor Technology / Energy Storage Devices (Apprenticeship-Embedded / Research Track)

Graduates of this four-year program will demonstrate the following specific outcomes upon successful completion:

- **PSO1. Core and Advanced Domain Expertise**

  Apply foundational and advanced knowledge of **industrial electronics and sensor technology** to analyze, model, and develop comprehensive solutions for real-world and emerging challenges in automation, control systems, embedded systems, and smart sensing.

- **PSO2. Problem Analysis and Application Orientation**

  Identify and analyze electronics-related problems of varying complexity using a conceptual and practical understanding of circuit design, instrumentation, signal processing, and sensor integration; formulate solutions that are technically sound and industry-relevant.

- **PSO3. Design and Development of Technological Solutions**

  Design and develop **innovative hardware and software-based solutions** in the domains of industrial electronics and sensor systems, addressing current and future needs of stakeholders, including industries, research labs, and society.

- **PSO4. Experimental Skills and Research Capability**

  Plan and conduct experiments using scientific methods; collect, analyze, and interpret data from laboratory investigations or field-based studies to draw meaningful conclusions, particularly in the context of **sensor applications or electronics-based research and development**.

- **PSO5. Application of Modern Tools and Industry Practices**

  Select and apply modern electronic design automation (EDA) tools, programming platforms, simulation software, and sensor technologies to address complex technical tasks. Understand the capabilities and limitations of these tools in **both industrial and research environments**, especially during the fourth-year **apprenticeship or research specialization**.

These PSOs are designed to produce **industry-ready professionals and research-oriented graduates** with capabilities in core electronics, smart sensing technologies, and system integration, aligned with the evolving needs of the **electronics sector and national innovation priorities**.

Eligibility:

Candidates who have passed **12th Science**, **MCVC**, or completed **2-year ITI** in a relevant branch shall be considered eligible for admission.

Course Fees:

Rs. 28020 per year

Number of Seats:

The Intake capacity of BSc. Electronics (Honours) will be 40 as under 'Self Finance Mode'

Admission / Promotion Process:

In response to the advertisement for registration, interested students will have to register themselves. One of the following methods will be adopted for admission.

- Admission will be done on the basis of performance of students at Common Entrance Test (CET). The CET will be conducted in the month of June every year.

OR

- Admission process declared by the University

Promotion rules will be as per the University scheme of examination for undergraduate programme

Choice Based Credit System (CBCS):

The choice-based credit system is going to be adopted by the University. This provides flexibility to make the system more responsive to the changing needs of our students, the professionals and society. It gives greater freedom to students to determine their own pace of study. The credit-based system also facilitates the transfer of credits.

Credit-to-contact hour Mapping:

- One Credit would mean equivalent of 15 contact hours each for theory lecture.
- One Credit would mean equivalent of 30 contact hours for lab course/ workshops/internship/field work/project.

Attendance:

Students must have 75 % of attendance in each course for appearing examination, otherwise he / she will be strictly not allowed for appearing the semester examination of each course. Frequent absence from regular lecture/practical course may lead to disqualification from continuous internal assessment (CIA) process in respective subject.

Departmental Committee:

The Departmental Committee (DC) of the Department will monitor smooth functioning of the program.

Results Grievances / Redressal Committee

Grievances / redressal committee will be constituted in the department to resolve all grievances relating to the evaluation. The committee shall consist of Head of the department, the concerned teacher of a particular course and senior faculty member of Department of Committee. The decision of Grievances / redressal committee will have to be approved by Department committee.

Evaluation Methods:

Evaluation methods will be as per the University scheme of examination for undergraduate programme.

Duration

Duration of the BSc Electronics Apprenticeship Embedded / Research Degree Programme (AERDP) shall be 3 years/ 6 semesters. (132 Credits) & BSc Electronics Honours – Apprenticeship Embedded / Research Degree Programme (AERDP) shall be 4 years/ 8 semesters. (176 Credits)

Programme Structure and Credit Distribution

Award Level	**Minimum Credits**	**NSQF Level**	**Duration**
UG Certificate	44	Level 5	One Year
UG Diploma	88	Level 6	Two Years
UG (BSc) Degree	132	Level 7	Three Years
UG (BSc Honours) Degree	176	Level 8	Four Years

Tripartite Agreement for Apprenticeship (Mandatory)

A formal agreement for Apprenticeship will be signed between:

- University Department
- Industry/Company/Startup
- Student (Apprentice)

Structure of the 4-Year Apprenticeship-Embedded / Research Degree Program (AERDP) B.Sc. Electronics (Hons)

(Major in Industrial Electronics and Minor in Sensor technology / Energy Storage Devices)

B.Sc. Electronics First Year: 1st Semester (NSQF Level 5.0)

\Course Type	Course Code	Course Name	Teaching Scheme (Hrs / Week)		Credits Assigned		Scheme of Examination		
			Theory	Practical	Theory	Practical	CIE	SEE	Total
Department Specific Course DSC (Major) Mandatory	SUB/DSC/T /100	Fundamental of Analog Electronics	2		2		20	30	50
	SUB/DSC/P /125	Practical based on (SUB/DSC/T/100)		4		2	20	30	50
	SUB/DSC/T /101	Fundamental of Digital Electronics	2		2		20	30	50
	SUB/DSC/P /126	Practical based on (SUB/DSC/T/101)		4		2	20	30	50
	SUB/DSC/T /102	Network Analysis and Semiconductor Devices	2		2		20	30	50
	SUB/DSC/P /127	Practical based on (SUB/DSC/T/102)		4		2	20	30	50
Generic / Open Elective (GE/OE) (Choose any one from pool of courses) **It should be chosen compulsorily from the faculty other than that of Major**	SUB/GE/ OE/T/100	Choose any one course from GE/OE Basket	2		2		20	30	50
SEC (Skill Enhancement Courses) (Choose any one from SUB/SEC/P/125 and SUB/SEC/P/126)	SUB/SEC/P /125	Consumer Electronics		4		2	20	30	50
	SUB/SEC/P /126	Electrical Wiring		4		2	20	30	50
AEC, VEC, IKS	SUB/AEC/ T/100	**English** (Common for all the faculty)	2		2		20	30	50
	SUB/IKS/T /101	Choose any one from pool of courses (IKS Basket)	2		2		20	30	50
OJT/ FP/CEP/CC/RP	SUB/CC/P/ 125	Health and Wellness (Common for all the faculty)		4		2	20	30	50
			12	**20**	**12**	**10**	**220**	**330**	**550**

GE/OE-1: Introduction to Electronics and Everyday Technology (This course will be available for the students of other faculty (other than Faculty of Science and Technology)

B.Sc. Electronics First Year: 2nd Semester (NSQF Level 5.0)

Course Type	Course Code	Course Name	Teaching Scheme (Hrs / Week)		Credits Assigned		Scheme of Examination		
			Theory	Practical	Theory	Practical	CIA	SEE	Total
Department Specific Course DSC (Major) Mandatory	SUB/ DSC/T/ 150	Linear Integrated Circuits	2		2		20	30	50
	SUB/DSC/P/ 175	Practical based on (SUB/ DSC/T/ 150)		4		2	20	30	50
	SUB/DSC/T/ 151	Power Electronics	2		2		20	30	50
	SUB/DSC/P 176	Practical based on (SUB/DSC/T/ 151)		4		2	20	30	50
	SUB/DSC/T/ 152	Measurements and Instrumentations	2		2		20	30	50
	SUB/DSC/P/ 177	Practical based on (SUB/DSC/T/152)		4		2	20	30	50
Generic / Open Elective (GE/OE) (Choose any one from pool of courses) **It should be chosen compulsorily from the faculty other than that of Major**	SUB/GE/OE/ T/ 150	Choose any one course from GE/OE Basket	2		2		20	30	50
VSC (Vocational Skill Courses) (Choose any one from SUB/VSC/P/175 and SUB/VSC/P/176)	SUB/VSC/P/ 175	PCB design and fabrication		4		2	20	30	50
	SUB/VSC/P/ 176	Power Supplies		4		2	20	30	50
AEC, VEC, IKS	SUB/AEC/T/ 150	Modern Indian Language (MIL-1) (Choose any one from pool of language courses)	2		2		20	30	50
	SUB/VEC/T /151	Constitution of India (Common for all the faculty)	2		2		20	30	50
OJT/ FP/CEP/CC/RP	SUB/CC/P/ 175	Yoga Education / Sports and Fitness (Common for all the faculty)		4		2	20	30	50
			12	**20**	**12**	**10**	**220**	**330**	**550**
Exit Option : Award of UG Certificate in Electronics with 44 credits and an additional 4 credits of core NSQF course / Internship OR continue with Major and Minor									

GE/OE-2 Introduction to DIY Solar & Smart Tech for Everyday Life (This course will be available for the students of other faculty (other than Faculty of Science and Technology)

B.Sc. Electronics Second Year: 3rd Semester (NSQF Level 6.0)

Course Type	Course Code	Course Name	Teaching Scheme (Hrs / Week)		Credits Assigned		Scheme of Examination		
			Theory	Practical	Theory	Practical	CIA	SEE	Total
Department Specific Course DSC (Major) Mandatory	SUB/DSC/ T/ 200	8086 Microprocessor and Programming	2		2		20	30	50
	SUB/DSC/ P/ 225	Practical based on (SUB/DSC/T/ 200)		4		2	20	30	50
	SUB/DSC/ T/ 201	Signals and Systems	2		2		20	30	50
	SUB/DSC/ P/ 226	Practical based on (SUB/DSC/T/ 201)		4		2	20	30	50
Minor	SUB/Mn/T/ 200	Sensor Fundamentals	2		2		20	30	50
	SUB/Mn/T/ 201	Fundamentals of Energy Storage Devices	2		2		20	30	50
Generic / Open Elective (GE/OE) (Choose any one from pool of courses) **It should be chosen compulsorily from the faculty other than that of Major**	SUB/GE/ OE/T/200	Choose any one course from GE/OE Basket	2		2		20	30	50
VSC (Vocational Skill Courses) (Choose any one from SUB/VSC/P/ 225 and SUB/VSC/P/ 226)	SUB/VSC/ P/ 225	Inverter-I		4		2	20	30	50
	SUB/VSC/ P/ 226	E-V Technology		4		2	20	30	50
AEC, VEC, IKS	SUB/AEC/ T/200	**English** (Common for all the faculty)	2		2		20	30	50
	SUB/VEC/ T/201	Environmental Studies	2		2		20	30	50
OJT/ FP/CEP/CC/RP	SUB/CC/P/ 225	Cultural Activity / NSS, NCC (Common for all the faculty)		4		2	20	30	50
			14	**16**	**14**	**8**	**220**	**330**	**550**

GE/OE-3: Introduction to Air Conditioners (This course will be available for the students of other faculty (other than Faculty of Science and Technology)

B.Sc. Electronics Second Year: 4th Semester (NSQF Level 6.0)

Course Type	Course Code	Course Name	Teaching Scheme (Hrs / Week)		Credits Assigned		Scheme of Examination		
			Theory	Practical	Theory	Practical	CIA	SEE	Total
Department Specific Course DSC (Major) Mandatory	SUB/DSC/T/ 250	8051 Microcontroller and Programming	2		2		20	30	50
	SUB/DSC/P/ 275	Practical based on (SUB/DSC/T/ 250)		4		2	20	30	50
	SUB/DSC/T/ 251	Embedded Systems and Interfacing (SUB/DSC/P/ 275)	2		2		20	30	50
	SUB/DSC/P/ 276	Practical based on (SUB/DSC/T/ 251)		4		2	20	30	50
Minor	SUB/Mn/T/ 250	Renewable Energy Sources	2		2		20	30	50
	SUB/Mn/T/ 251	Fundamentals of Solar Energy Systems	2		2		20	30	50
Generic / Open Elective (GE/OE) (Choose any one from pool of courses) **It should be chosen compulsorily from the faculty other than that of Major**	SUB/GE/OE/T /250	Choose any one course from GE/OE Basket	2		2		20	30	50
SEC (Skill Enhancement Courses) (Choose any one from SUB/SEC/P/ 275 and SUB/SEC/P/ 276) and corresponding Practical's	SUB/SEC/P/ 275	Inverter-II		4		2	20	30	50
	SUB/SEC/P/ 276	Arduino Programming and Interfacing		4		2	20	30	50
AEC, VEC, IKS	SUB/AEC/T/ 250	Modern Indian Language (MIL-2) (Choose any one from pool of language courses)	2		2		20	30	50
OJT/ FP/CEP/CC/RP	SUB/FP/P/ 275	Field Project-1		4		2	20	30	50
	SUB/CC/P/ 276	(Fine/ Applied/ Visual/ Performing Arts) (Common for all the faculty)		4		2	20	30	50
			12	**20**	**12**	**10**	**220**	**330**	**550**
Exit Option : Award of UG Diploma in major and minor with 88 credits and an additional 4 credits NSQF course (related to major / minor) / Internship during summer vacation OR Continue with Major and Minor									

GE/OE-4: Introduction to Refrigeration (This course will be available for the students of other faculty (other than Faculty of Science and Technology)

B.Sc. Electronics Third Year: 5th Semester (NSQF Level 7.0)

Course Type	Course Code	Course Name	Teaching Scheme (Hrs / Week)		Credits Assigned		Scheme of Examination		
			Theory	Practical	Theory	Practical	CIA	SEE	Total
Department Specific Course DSC (Major) Mandatory	SUB/DSC/T/ 300	Industrial Robotics	2		2		20	30	50
	SUB/DSC/P/ 325	Practical based on (SUB/DSC/T/ 300)		4		2	20	30	50
	SUB/DSC/T/ 301	Control System	2		2		20	30	50
	SUB/DSC/P/ 326	Practical based on (SUB/DSC/T/ 301)		4		2	20	30	50
	SUB/DSC/T/ 302	Industrial IoT	2		2		20	30	50
Discipline Specific Electives (DSE) (Choose any one from SUB/DSE/T/ 300 and SUB/DSE/T/ 301) and corresponding Practical's	SUB/DSE/T/ 300	Optical Fiber Communication	2		2		20	30	50
	SUB/DSE/P/ 325	Practical based on (SUB/DSE/T/ 300)		4		2	20	30	50
	SUB/DSE/T/ 301	PLC and SCADA	2		2		20	30	50
	SUB/DSE/P/ 326	Practical based on (SUB/DSE/T/ 301)		4		2	20	30	50
Minor	SUB/Mn/T/ 300	Temperature and Humidity Sensor	2		2		20	30	50
	SUB/Mn/T/ 301	Fundamentals of Batteries and Fuel cell	2		2		20	30	50
VSC (Vocational Skill Courses) (Choose any one from SUB/VSC/P/ 325 and SUB/VSC/P/ 326)	SUB/VSC/P/ 325	Industrial Automation and Control		4		2	20	30	50
	SUB/VSC/P/ 326	Sensor Technology		4		2	20	30	50
OJT/ FP/CEP/CC/RP (Choose any one from pool of courses)	SUB/FP/CEP /P/325	Field Project-2		4		2	20	30	50
			12	**20**	**12**	**10**	**220**	**330**	**550**

B.Sc. Electronics Third Year: 6^{th} Semester (NSQF Level 7.0)

<table>
<tr><td colspan="6" align="center">Apprenticeship
Mandatory Apprenticeship Program in 6th Semester

To bridge the gap between academic knowledge and practical industry experience, an apprenticeship program has been made compulsory for all students in the 6th semester. This initiative aims to ensure that students gain hands-on exposure to real-world applications in their respective fields of study. Students will be advised to join the respective Industry anywhere across the country as per opportunities found on NAPS, NATS, BOAT and BOPT portal.</td></tr>
<tr><td rowspan="2">Course Name</td><td rowspan="2">Teaching Scheme
(Hrs / Week)</td><td rowspan="2">Credits Assigned</td><td colspan="3">Scheme of Examination</td></tr>
<tr><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>Apprenticeship-1</td><td>44</td><td>22</td><td>220</td><td>330</td><td>550</td></tr>
<tr><td colspan="6" align="center">Exit option : Award of UG degree in Major with 132 credits and an additional 4 credits Internship during summer vacation OR continue to fourth year apprenticeship in Industry / research oriented courses in the Department</td></tr>
</table>

B.Sc. Electronics Fourth Year: 7th Semester (NSQF Level 8.0)

Course Type	Course Code	Course Name	Teaching Scheme (Hrs/Week)		Credits Assigned		Scheme of Examination		
			Theory	Practical	Theory	Practical	CIA	SEE	Total
Department Specific Course DSC (Major) Mandatory	SUB/DSC/ T/ 400	Synthesis and Characterisation Techniques for Advanced Materials	2		2		20	30	50
	SUB/DSC/ P/ 425	Practical based on SUB/DSC/T/400		4		2	20	30	50
	SUB/DSC/ T/ 401	Electrochemical Sensors and Energy Storage Devices	2		2		20	30	50
	SUB/DSC/ P/ 426	Practical based on SUB/DSC/T/401		4		2	20	30	50
	SUB/DSC/ T/ 402	Properties of Materials and Fundamentals and Device Fabrication	2		2		20	30	50
Discipline Specific Electives (DSE) (Choose any one from SUB/DSE/T / 400 and SUB/DSE/T / 401) and corresponding Practical's	SUB/DSE/ T / 400	Chemiresistive & Chem-FET Gas Sensors: Principles and Applications	2		2		20	30	50
	SUB/DSE/ T / 401	Electrocatalysis: Principles and Applications	2		2		20	30	50
	SUB/DSE/ P / 425	Practical based on SUB/DSE/T / 400		4		2	20	30	50
	SUB/DSE/ P / 426	Practical based on SUB/DSE/T /401		4		2	20	30	50
Research Project	SUB/RP/P/ 425	Research Project		16		8	80	120	200
			08	**28**	**08**	**14**	**220**	**330**	**550**

In the 4^{th} year 8^{th} Semester student will have two options,

1. **One Semester that is (8^{th} semester) apprenticeship in Industry** **(Students will get Four Year Apprenticeship Embedded Under graduate Degree in Major and Minor with 176 Credits)**
2. **Extensive research training in the Department** **(Students will get Four Year UG Honours Degree with Research in Major and Minor with 176 Credits)**

Option 1. Industry Apprenticeship Track: One Semester **apprenticeship in a relevant industry**, enabling students to gain hands-on experience, workplace skills, and industry insights under real-world conditions—facilitated through NAPS apprenticeship frameworks and Industry partnerships **(22 Credits).** Students will be advised to join the respective Industry anywhere across the country as per opportunities found on NAPS, NATS, BOAT and BOPT portal.

B.Sc. Electronics Fourth Year: 8^{th} Semester (NSQF Level 8.0)

Option-1

Apprenticeship at Industry
Apprenticeship Program in 8th Semester

To bridge the gap between academic knowledge and practical industry experience, an apprenticeship program has been one of the options for the students in the 8th semester. This initiative aims to ensure that students gain hands-on exposure to real-world applications in their respective fields of study.

Course Name	Teaching Scheme (Hrs / Week)	Credits Assigned	Scheme of Examination		
			CIA	SEE	Total
Apprenticeship-2	44	22	220	330	550
Four Year UG Honours Degree in Major and Minor with 176 Credits					

Option-2

Extensive Research Training at Department of Electronics
Dr. Babasaheb Ambedkar Mareathwada University

During the 8th semester, students will be actively engaged in extensive research on the synthesis and characterization of advanced materials for sensor and supercapacitor applications. This activity focuses on developing functional materials with enhanced sensitivity, efficiency, and energy storage capabilities. Through hands-on experimentation and project-based learning, students gain practical exposure to modern fabrication techniques and testing methods, preparing them for research and industry in emerging electronic technologies.

Course Name	Teaching Scheme (Hrs / Week)	Credits Assigned	Scheme of Examination		
			CIA	SEE	Total
Research Training	44	22	220	330	550
Four Year UG Honours Degree in Major and Minor with 176 Credits					

Semester - III

SUB/DSC/T/200
8086 Microprocessor and Programming
(Credits:02 Contact hours: 30 Marks:50)

Course objectives:

1. **To develop a strong foundational understanding** of microprocessor systems by:
   a) **Introducing the fundamental concepts, architecture, and operation** of microprocessors.
   b) **Building competence in assembly language programming**, enabling students to write, analyze, and debug programs effectively.
2. **To cultivate problem-solving and system-level thinking skills** by applying microprocessor concepts to real-world applications and embedded system design.
3. **To enhance practical and technical proficiency** through exposure to programming tools, hardware interfacing, and hands-on experimentation.
4. **To foster innovation and entrepreneurial mindset** by encouraging students to explore microprocessor-based solutions for societal and industrial challenges, thereby enabling them to pursue **start-up opportunities and self-employment** in embedded systems and electronics domains.

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

CO1: Explain and interpret the architecture of microprocessors, including physical and logical memory organization, and demonstrate basic programming concepts.
(Bloom's Level: Understand)

CO2: Analyze and evaluate microprocessor-based systems used in industrial automation applications.
(Bloom's Level: Analyze / Evaluate)

CO3: Develop, debug, and optimize programs using assembly language for microprocessor-based systems.
(Bloom's Level: Apply / Analyze)

CO4: Design and develop microprocessor-based automated devices, demonstrating the ability to translate technical knowledge into entrepreneurial solutions.
(Bloom's Level: Create)

CO5: Apply and communicate fundamental concepts of microprocessors effectively in academic and professional settings, enabling readiness for teaching and knowledge dissemination.
(Bloom's Level: Apply)

Unit	Content	Lectures
Unit 1	**Introduction** Overview of Microcomputer structure and operation, memory, input / output, CPU, address bus, data bus, control bus, 8086 microprocessor family overview, **8086 internal architecture:** execution unit, (flag register, general purpose register, ALU), Bus interface unit, segment register, stack pointer register, pointer and index register [Refer Douglas and Hall book for above articles], **Pin out and pin functions of 8086 :** The pin out, power supply requirements, DC characteristics, input characteristics, output characteristics, pin connections (common pins, maximum mode pins and minimum mode pins) **Addressing Modes**: Data addressing modes: Register addressing, Immediate addressing, Direct addressing, register indirect addressing, base plus index addressing, register relative addressing, base relative plus index addressing, Programme memory addressing modes: Direct program memory addressing, relative program memory addressing, indirect program memory addressing; stack memory addressing modes.	10 L
Unit 2	**Data Movement, Arithmetic and Logical Instructions** **MOV revised:** machine language, the opcode, MOD field, register assignments, R/M memory addressing, special addressing, **PUSH/POP :** PUSH, POP, initializing the stack**; Miscellaneous data transfer instructions:** XCHG, IN and OUT, **Arithmetic and Logic Instructions: Addition, subtraction and comparison: Addition:** Register addition, immediate addition, memory to register addition, array addition, increment addition, addition with carry**; Subtraction:** Register subtraction, immediate subtraction, decrement subtraction, subtraction with barrow**; Comparison, Multiplication and division**: **Multiplication**: 8 bit multiplication, 16 bit multiplication; **Division:** 8 bit division, 16 bit division; **Basic Logic Instructions:** AND, OR, Ex-OR, TEST, NOT, NEG**; Shift and Rotate: Shift:** left shift, right shift; **Rotate:** Rotate left, rotate right	10 L
Unit 3	**Program Control Instructions and Assembly Language Programming** **The Jump Group**: **Unconditional jump:** short jump, near jump, far jump, indirect jumps using an index; **Conditional Jumps:** LOOP, conditional LOOPs; **Procedures**: CALL, near CALL, far CALL, indirect memory address, RET; **Machine Control and Miscellaneous Instructions:** Controlling the carry flag bit, wait, HLT, NOP; **Assembly Language Programming: Assembler directives:** ASSUME, DB, DD, DQ, DT, DW, END, ENDP, ENDS, EQU, EVEN, EXTRN, GLOBAL, GROUP, INCLUDE, LABEL, LENGTH, NAME, OFFSET, ORG, PROC, PTR, PUBLIC, SEGMENT, SHORT, TYPE [Refer Douglas and Hall book for above articles **Assembly Language Programming:** Sum of an array, factorial, largest / smallest from given array, sorting of numeric array, square root.	10 L

Suggested Readings:

1. The Intel Microprocessors, Architecture Programming and interfacing, Barry B Brey ; Sixth Edition ; Prentice Hall International, Publications, **(2002),** ISBN-10: 0130607142, ISBN-13: 978-0130607140
2. The Intel Microprocessors, Architecture Programming and interfacing, Barry B Brey ;Eighth Edition ; Prentice Hall International, Publications **(2009),** ISBN 0-13-502645-8

3. Microprocessors and Interfacing: Programming and Hardware, Douglas V Hall : II Edition ; Tata McGraw-Hill **(1990),** ISBN-10: 0070257426, ISBN-13: 978-0070257429.
4. Microcomputer Systems: The 8086 / 8088 Family; Architecture, Programming and Design, Yu-Cheng Liu and Glenn A. Gibson, Prentice Hall International, Publications **(1986),** ISBN-10: 013580499X, ISBN-13: 9780135804995.
5. The 8086/8088 Family: Design, Programming and Interfacing, John, Uffenbeck, Prentice Hall International, Publications **(1986),** ISBN-10: 0132467526, ISBN-13: 978-0132467520

SUB/ DSC/P/ 225: Practical Based On
8086 Microprocessor and Programming
(Credit: 02 Contact Hrs.: 60 Marks: 50)

1. Data Transfer Operations Using 8086 Trainer Kit
2. Addition of Numbers Using 8086 Trainer Kit
3. Subtraction of Numbers Using 8086 Trainer Kit
4. Multiplication of Numbers Using 8086 Trainer Kit
5. Division of Numbers Using 8086 Trainer Kit
6. Factorial of the number using 8086 trainer kit.
7. Square of the number using 8086 trainer kit.
8. Sorting of data Ascending, obtaining square root of number using 8086 trainer kit.
9. Sorting of data Descending, obtaining square root of number using 8086 trainer kit.
10. Arithmetic mean of N numbers and sum of square of Numbers using 8086 trainer kit.

(At least Eight experiments from the prescribed list of experiments should be performed successfully.)

SUB/DSC/T/201
Signals and Systems
(Credits:02 Contact hours: 30 Marks:50)

	Course objectives: 1. **To develop foundational understanding of signals and systems by:** a) Introducing concepts, classification, and representation of continuous and discrete signals. b) Explaining signal properties such as energy, power, periodicity, and symmetry. 2. **To build system analysis skills by:** a) Introducing system properties like linearity, time-invariance, causality, and stability. b) Analyzing LTI systems using convolution, impulse response, and interconnections. 3. **To enhance problem-solving using transform techniques by:** a) Applying Fourier series, Fourier transform, and DTFT for frequency analysis. b) Using Laplace and Z-Transform for system analysis and solving equations. 4. **To strengthen practical understanding by:** a) Explaining sampling theorem, Nyquist rate, aliasing, and reconstruction. b) Interpreting ESD and PSD. 5. **To promote application and innovation by:** Applying concepts in communication, control systems, and signal processing domains.	
	Learning Outcomes **By the end of this course, students will be able to:** **CO1 (Understand)** Explain and interpret the architecture of microprocessors, including physical and logical memory organization, and basic programming concepts. **CO2 (Analyze/Evaluate)** Analyze and evaluate microprocessor-based systems used in industrial automation applications. **CO3 (Apply/Analyze)** Develop, debug, and optimize assembly language programs for microprocessor-based systems. **CO4 (Create)** Design and develop microprocessor-based automated devices and embedded solutions with entrepreneurial perspective. **CO5 (Apply)** Apply and communicate microprocessor concepts effectively in academic and professional environments.	
Unit 1	**Fundamentals of Signals and Systems** **Signals** • Definition and classification: Continuous-time & Discrete-time • Energy and Power signals • Even and Odd signals • Periodic and Non-periodic signals	**10 L**

	• Signal representation: Graphical, Functional, Tabular, Sequence **Basic Signals** • Unit impulse, Unit step, Ramp, Parabolic • Rectangular, Triangular, Signum • Sinusoidal, Real & Complex exponential • Sinc and Gaussian functions **Operations on Signals** • Addition, subtraction • Time shifting, scaling, reversal **Systems** • Definition and classification • Static & Dynamic systems • Linear & Non-linear systems • Time-invariant & Time-variant systems • Causal & Non-causal systems • Stable & Unstable systems • Invertible & Non-invertible systems • System interconnections **Real-Life Examples** • Signals: Speech, ECG, EEG, EMG • Systems: Communication systems, Control systems	

Unit 2	**Systems and Time-Domain Analysis**
	LTI Systems
	• Input-output relationship
	• Impulse response and step response
	• Representation of LTI systems
	Convolution
	• Convolution sum (Discrete-time)
	• Convolution integral (Continuous-time)
	• Methods: Graphical and tabular
	• Standard cases:
	    o Step–step
	    o Step–exponential
	    o Exponential–exponential
	    o Step–rectangular
	    o Rectangular–rectangular
	Properties
	• Properties of convolution
	• System properties using impulse response
	Correlation
	• Autocorrelation and Cross-correlation
	• Significance and interpretation
	Applications
	• Speech recognition
	• Voice assistants
	• Real-time translation
	• Medical signal processing
		10 L

Unit 3	**Transform Techniques and Applications** **Signals** • Definition and classification: Continuous-time & Discrete-time • Energy and Power signals • Even and Odd signals	**10 L**

	• Periodic and Non-periodic signals • Signal representation: Graphical, Functional, Tabular, Sequence **Basic Signals** • Unit impulse, Unit step, Ramp, Parabolic • Rectangular, Triangular, Signum • Sinusoidal, Real & Complex exponential • Sinc and Gaussian functions **Operations on Signals** • Addition, subtraction • Time shifting, scaling, reversal **Systems** • Definition and classification • Static & Dynamic systems • Linear & Non-linear systems • Time-invariant & Time-variant systems • Causal & Non-causal systems • Stable & Unstable systems • Invertible & Non-invertible systems • System interconnections **Real-Life Examples** • Signals: Speech, ECG, EEG, EMG • Systems: Communication systems, Control systems	
Suggested Readings: 1. Signals and Systems – Alan V. Oppenheim & Alan S. Willsky. 2. Signals and Systems – Simon Haykin & Barry Van Veen. 3. Signals and Systems – B.P. Lathi. 4. Principles of Linear Systems and Signals – B.P. Lathi.		

	SUB/ DSC/P/226: Practical Based on Signals and Systems **(Total Credits: 02 Contact Hours: 60 Hrs Maximum Marks: 50)**	
	1. Generation and classification of continuous and discrete signals 2. Operations on signals (time shifting, scaling, reversal) 3. Determination of energy and power of signals 4. Even and odd decomposition of signals 5. Linear convolution of two signals 6. Convolution using graphical method 7. Verification of LTI system properties	

	8. Autocorrelation and cross-correlation of signals 9. Computation of Fourier Series 10. Computation of Fourier Transform / DTFT 11. Computation of Laplace Transform and inverse Laplace Transform 12. Verification of sampling theorem and aliasing effect **(At least Eight experiments from the prescribed list of experiments should be performed successfully.)**	

	SUB/Mn/T/200 **Sensor Fundamentals** **(Credits:02 Contact hours:30 Marks:50)**	
	Course objectives: 1. To develop a strong foundational understanding of sensor technology by: 2. a) Introducing the fundamental concepts and classification of sensors. 3. b) Explaining the underlying operating principles of various types of sensors. 4. To cultivate analytical and research-oriented thinking, enabling students to explore advanced concepts and emerging trends in sensor technology.	

	5. To provide exposure to research opportunities in the field of sensors, encouraging students to engage in innovative and interdisciplinary investigations. 6. To inspire curiosity and foster enthusiasm among students to pursue research and development in sensor technologies, particularly for real-world and societal applications.	
	Learning Outcomes **By the end of this course, students will be able to:** **CO1:** Explain and interpret the fundamental concepts of sensors, including classification, ideal characteristics, and performance parameters such as sensitivity, accuracy, resolution, and stability. (Bloom's Level: Understand) **CO2:** Analyze sensor characteristics and calibration processes to evaluate sensor performance, errors, and limitations in practical applications. (Bloom's Level: Analyze) **CO3:** Explain the working principles and configurations of optical sensors, including photodetectors, optical fibers, and modulation-based sensing techniques. (Bloom's Level: Understand) **CO4:** Analyze and compare various physical sensors (such as LVDT, piezoelectric, capacitive, resistive, and inductive sensors) for different measurement applications. (Bloom's Level: Analyze) **CO5:** Design and develop sensor-based systems by selecting appropriate sensors and integrating them for real-world applications, including biomedical and industrial systems. (Bloom's Level: Create)	
Unit 1	**Sensor Fundamentals, Data Acquisition and Transfer Functions:** Sensors, Signals, and Systems; Ideal sensor curve, ideal sensor requisite, Sensor Classifications ; Sensor Characteristics: Transfer Function; Span (Full-Scale Input) ; Full-Scale Output ; Accuracy ; Calibration ; Calibration Error ; Hysteresis; Nonlinearity ; Saturation ; Repeatability ; Dead Band ; Resolution ; Parameters of sensors : Sensitivity, detection limit, response and recovery time, selectivity, dynamic range, linearity, stability	**10 L**
Unit 2	**Sensors in Engineering and Physical Principles of Sensing:** Introduction of light detectors: Photodiodes, Phototransistor , Photoresistors ; photovoltaic cell, Optical waveguides and fibres, types of optical fibers : single mode, multimode and graded index optical fiber, concept of TIR and ATR, Optical fibre sensors: Introduction and classification of sensors with optical fibres, Optical fibre sensors with amplitude modulation, Sensor with wavelength modulation; Optical chemical sensors: Introduction, Optical sensors: Methods of detection, Evanescent wave sensors.	**10 L**

Unit 3	**Displacement Sensors and Light Detectors:** Potentiometric Sensors; Gravitational Sensors; LVDT and RVDT , Eddy Current Sensors , Piezoelectric sensors, Resistive Sensors: Potentiometers, Strain gages; Inductive sensors, Capacitive sensors, Bridge circuits, Displacement Measurements, Blood Pressure Measurements: Extravascular sensors, Intravascular sensors, Disposable pressure sensors	**10 L**
	Suggested Readings: 1. Chemical Sensors: An Introduction for Scientists and Engineers : Grundler, Peter; Springer Berlin Heidelberg New York **(2007),** ISBN 978-3-540-45742-8 2. Modern Sensors Handbook, Edited by Pavel Ripka and Alois Tipek; ISTE Ltd, USA **(2007)**, ISBN 978-1-905209-66-8. 3. Handbook of Chemical and Biological Sensors; Edited by Richard F Taylor, Arthur D Little Inc., Jerome S Schultz, University of Pittsburgh ; Institute of Physics Publishing Bristol and Philadelphia; **(1996)** ISBN 0 7503 0323 9 4. Hand Book of Modern Sensors : Physics, Designs and Applications By Jacob Fraden Third Edition (Springer-Verlag New York, Inc.) **(2004)**, ISBN 0-387-00750-4. 5. Understanding Smart Sensors By Randy Frank; Second Edition; Artech House Boston . London **(2000),** ISBN 1-58053-398-1. 6. Sensors and Transducers, Third Edition By Ian R. Sinclair; Butterworth-Heinemann publication, Woburn **(2001),** ISBN 0 7506 4932 1 7. Principles of Chemical Sensors : Janata, Jiri 2nd Edition ; Springer Dordrecht Heidelberg London, New York **(2009),** ISBN 978-0-387-69930-1 e-ISBN 978-0-387-69931-8 8. Optoelectronics Devices and System SECOND EDITION by S. C. Gupta; Prentice Hall International **(2011)** ISBN: 978-81-203-5065-6 9. Optical Fibers and fiber optic communication Systems by Subir Kumar Sarkar; S Chand & Company Ltd **(2000),** ISBN: 9788121914598 10. Lasers and Optical Fiber Communications by P Sarah; I.K. International Publishing House Pvt Ltd, New Delhi **(2008),** ISBN : 9788189866587 / 8189866583 11. Optoelectronics by R. A. Barapate (Tech-Max Publication) **(2003)**	

	SUB/Mn/T/201 **Fundamentals of Energy Storage Devices** **(Credits:02 Contact hours:30 Marks:50)**	
	Course objectives: 1. To understand the basic concepts and working of electrochemical cells and energy storage mechanisms. 2. To study different types of batteries and their construction, characteristics, and applications. 3. To analyze battery performance, charging–discharging processes, and safety aspects. 4. To learn battery manufacturing techniques and explore hybrid energy storage systems for practical and industrial applications	

	Learning Outcomes **By the end of this course, students will be able to:** **CO1:** Analyze and evaluate different types of batteries such as lead–acid, nickel–cadmium, lithium-ion, and alkaline batteries based on their construction, materials, working, and applications. **CO2:** Apply knowledge of charging–discharging processes and assess battery performance parameters such as energy density, power density, efficiency, internal resistance, and cycle life. **CO3:** Analyze battery manufacturing processes including material selection, electrode preparation, coating, drying, and industrial requirements. **CO4:** Evaluate issues related to battery operation such as overcharging, self-discharge, and safety, and justify the use of hybrid energy storage systems for improved performance. **CO5:** Design and propose solutions involving hybrid energy storage systems by integrating batteries with other energy storage technologies for enhanced efficiency and extended life. (Bloom's Level: Apply)	
Unit 1	**Basic Concepts and Batteries** Basic concepts: construction and working principle of electrochemical cells, anode and cathode reactions, self-discharge, shelf life, charge–discharge characteristics. Concept of reversible and irreversible electrochemical cells; definition and thermodynamic conditions of reversibility; Electrochemical basis of energy storage: oxidation–reduction reactions and conversion of chemical energy into electrical energy; structure and working of an electrochemical cell; anode and cathode processes; electrolyte and ionic conduction; electrode potential and standard electrode potential; electromotive force (EMF) of a cell	**10 L**
Unit 2	**Construction and Type of Batteries** Construction and working principle of lead–acid battery; components and materials: positive plate (lead dioxide), negative plate (spongy lead), electrolyte (dilute sulfuric acid), separators and container; electrochemical reactions during charge and discharge: characteristics of lead–acid battery: internal resistance, efficiency, cycle life, energy density and self-discharge; charging methods and charge control; applications of lead–acid batteries in automobiles; Construction and working principle of nickel–cadmium battery; Construction and working principle of lithium–ion battery; components and materials: Construction and working principle of alkaline battery; components and materials:	**10 L**
Unit 3	**Battery Performance and Manufacturing**	

	Concept of charging and discharging processes in electrochemical batteries; Concept and importance of energy density and power density in electrochemical energy storage devices.; Concept of overcharging in electrochemical batteries; conditions leading to overcharge when charging continues after full state of charge; electrochemical processes during overcharge: Overview of battery manufacturing processes and industrial requirements; selection and preparation of electrode active materials; mixing and slurry preparation with binders and conductive additives; coating of electrode slurry on current collectors and drying; calendaring and thickness control of electrodes; Concept of hybrid energy storage systems; need for coupling batteries with other energy storage devices; advantages of coupling: improved power delivery, energy efficiency, fast charge–discharge capability and extended battery life	**10 L**
	Suggested Readings: 1. A. J. Bard, L. R. Faulkner, Electrochemical Methods, Fundamentals and Application. Wiley, 2001. 2. C. Daniel and Jurgen O. Besenhard, Handbook of Battery Materials, Wiley-VCH Verlag, 2011. 3. K. E. Aifantis, S. A. Hackney, and R. V. Kumar (Ed.) High Energy Density Lithium Batteries Materials, Engineering, 4. Applications, WILEY-VCH Verlag GmbH & Co. KGaA, 2010. 5. A. Yu, V. Chabot, and J. Zhang, Electrochemical Supercapacitors for Energy Storage and 6. Delivery Fundamentals And Applications, Taylor & Francis Group, 2013. 7. F. Beguin and E. Frackowiak, Supercapacitors- Materials, Systems, and Applications. Wiley- VCH.	

	SUB/ VSC/P/ 225: Practical Based on Inverter-1 **(Credit: 02 Contact Hrs.: 60 Marks: 50)**	

Course Objectives

- Understand the basic concepts of power electronics, DC to AC conversion, and the role of inverters in practical applications.
- Explain and interpret the working principles, circuit diagrams, and output waveforms of single-phase half-bridge and full-bridge inverters.
- Analyze and compare different inverter configurations based on performance, output waveform, and applications.
- Apply Pulse Width Modulation (PWM) techniques using IC 555 and microcontrollers for controlling inverter output.
- Explain and analyze the structure, working, and switching characteristics of MOSFETs and their advantages in inverter circuits.
- Demonstrate the ability to design basic inverter circuits and implement PWM control techniques in laboratory or simulation environments.

Course Outcomes (COs)

After completing this course, students will be able to:

1. Explain the fundamentals of power electronics and the need for DC to AC conversion in practical applications.
   Bloom's Level: Understand (L2)
2. Illustrate the working principle, circuit diagram, and output waveform of single-phase half-bridge and full-bridge inverters.
   Bloom's Level: Understand (L2)
3. Compare half-bridge and full-bridge inverters based on performance, output, and applications.
   Bloom's Level: Analyze (L4)
4. Apply PWM generation using IC 555 and microcontroller for controlling inverter output.
   Bloom's Level: Apply (L3)
5. Analyze the structure, working, and switching characteristics of MOSFETs and justify their advantages in power electronics.
   Bloom's Level: Analyze (L4)
6. Analyze output waveforms and evaluate inverter performance using simulation tools or experimental setup.
   Bloom's Level: Analyze (L4)

	1. Study of Power Electronic Components)Identify and test BJT, MOSFET, IGBT using a multimeter) 2. Study of Single-Phase Half-Bridge Inverter 3. Study of Single-Phase Full-Bridge (H-Bridge) Inverter 4. PWM Generation using IC 555 5. PWM Generation using Microcontroller 6. Measurement of Inverter Output Voltage and Frequency 7. Study of MOSFET as an Inverter Switch 8. Observation of Square Wave Output using CRO 9. LC Filter Design 10. Series Inverter Circuit Testing 11. Simulate the single-phase inverter using the sinusoidal PWM 12. Study of Protection Circuits in Inverters 13.Simulation of Inverter Circuits **(At least Ten experiments from the prescribed list of experiments should be performed successfully.)**	

	SUB/VSC/P/225 **Inverter-I** **(Theoretical foundations of the experiments shall be acquired through self-study)**	
Unit 1	**Basics of Inverters** Introduction to Power Electronics, Need for DC to AC conversion, Inverter: Definition, basic principle and applications, Single-Phase Half-Bridge Inverter-Circuit diagram, working principle, Output waveform, Single-Phase Full-Bridge (H-Bridge) Inverter-Circuit diagram, Switching sequence, Output voltage waveform, Comparison between Half-Bridge and Full-Bridge Inverters	
Unit 2	**PWM Techniques and Switching Devices** Introduction to Pulse Width Modulation (PWM), Importance of PWM in inverter circuits, PWM Generation using IC 555, A stable mode operation, Duty cycle control, WM Generation using Microcontroller, Basic concept of digital PWM, Advantages over analog PWM, MOSFET as an Inverter Switch-Structure and working of MOSFET, Switching characteristics, Advantages of MOSFET in power electronics	
Unit 3	**Output Waveform Analysis and Simulation** Measurement of Inverter Output Voltage and Frequency, Use of CRO (Cathode Ray Oscilloscope) for waveform observation, Square Wave Output in inverter circuits, Parameters of square wave (amplitude, time period, frequency, duty cycle)	
	Suggested Readings: 1. M. H. Rashid – Power Electronics: Circuits, Devices and Applications 2. P.S. Bimbhra – Power Electronics 3. V.K. Mehta – Principles of ElectronicsMuhammad H. Rashid – Power Electronics Handbook	

SUB/VSC/P/226
E-V Technology
(Credit: 02 Contact Hrs.: 60 Marks: 50)

Course Objectives

1. To understand electrochemical principles and operation of batteries, fuel cells, and supercapacitors.
2. To study types of batteries and characteristics of lithium-ion batteries.
3. To learn charging, discharging, and testing methods of batteries.
4. To understand the working of Battery Management System (BMS).
5. To study EV components and analyze BLDC/DC motor performance with PWM control.
6. To understand EV charging methods and advanced systems like regenerative braking.

Course Outcomes

After completing this course, students will be able to:

CO1: Explain the electrochemical principles and working of batteries, fuel cells, and supercapacitors. Bloom's Level: Understand (L2)
CO2: Differentiate various battery types and analyze lithium-ion battery characteristics. Bloom's Level: Analyze (L4)
CO3: Explain battery charging/discharging behavior and testing methods. Bloom's Level: Understand (L2)
CO4: Describe the working and functions of Battery Management Systems (BMS). Bloom's Level: Understand (L2)
CO5: Analyze EV components and evaluate BLDC/DC motor performance with PWM control. Bloom's Level: Analyze (L4)
CO6: Compare EV charging methods and evaluate regenerative braking and EV drive system performance. Bloom's Level: Analyze (L4)

SUB/ VSC/P/ 226: Practical Based on E-V Technology
(Credit: 02 Contact Hrs.: 60 Marks: 50)

1. Study of different components of Electric Vehicle (EV) system (Motor, Battery, Controller, Charger).
2. Study and testing of Lithium-ion battery characteristics (Voltage, Current, Charging and Discharging).
3. Study of Battery Management System (BMS).
4. Study and performance analysis of BLDC motor used in EV.
5. Speed control of DC/BLDC motor using PWM technique USING STM 32 controller.
6. Study of EV charging methods (Level 1, Level 2, Fast charging).
7. Measurement of efficiency of electric motor used in EV.
8. Study of regenerative braking system.
9. Study of different components of Electric Vehicle (EV) system (Motor, Battery, Controller, Charger).
10. Study and testing of Lithium-ion battery characteristics (Voltage, Current, Charging and Discharging).
11. Study of Battery Management System (BMS).

	12. Study and performance analysis of BLDC motor used in EV. **(At least ten experiments from the prescribed list of experiments should be performed successfully.)**	
	SUB/VSC/P/226 **E-V Technology** **(Theoretical foundations of the experiments shall be acquired through self-study)**	
Unit 1	**Introduction to Battery Systems and Electric Vehicles** Electrochemical principle and reaction, Principle of operation of cells and batteries, Types of batteries, Fuel cells and supercapacitor, Study and testing of Lithium-ion battery characteristics (Voltage, Current, Charging & Discharging), Study of Battery Management System (BMS), Study of different components of Electric Vehicle (Motor, Battery, Controller, Charger)	**10 L**
Unit 2	**Motor Performance and Control** Study and performance analysis of BLDC motor used in EV, Speed control of DC/BLDC motor using PWM technique, Measurement of efficiency of electric motor used in EV	**10 L**
Unit 3	**EV Operation and Advanced Systems** Study of EV charging methods (Level 1, Level 2, Fast charging), Study of regenerative braking system, Performance testing of EV drive system (simulation or hardware based)	**10 L**
	Suggested Readings: 1. James Larminie, John Lowry – Electric Vehicle Technology Explained 2. Mehrdad Ehsani – Modern Electric, Hybrid Electric, and Fuel Cell Vehicles 3. Iqbal Husain – Electric and Hybrid Vehicles: Design Fundamentals 4. Davide Andrea – Battery Management Systems for Large Lithium-Ion Battery Packs 5. M. H. Rashid – Power Electronics: Circuits, Devices and Applications	

	GE/OE-3: Introduction to Air Conditioners (Credit: 02 Contact Hrs.:30 Marks: 50) This course will be available for the undergraduate students from **the Faculty of Humanities** and **Faculty of Commerce and Management** with **no prior background in electronics or engineering**	
	Learning Objectives: 1. Understand the basic concepts of air conditioning, including temperature, humidity, and human comfort conditions, and differentiate between cooling, refrigeration, and air conditioning. 2. Explain the basic refrigeration cycle and the functions of key components such as compressor, condenser, expansion valve, and evaporator. 3. Identify and describe different types of air conditioners, including window, split, portable, central, and inverter AC systems. 4. Understand energy consumption in air conditioners and interpret energy efficiency measures such as the BEE star rating system. 5. Recognize and explain the applications of air conditioning systems in residential, commercial, and industrial sectors.	
	Course Outcomes **After completion of the course, students will be able to:** **Cos1:** Explain the fundamental principles of air conditioning, including temperature, humidity, and human comfort conditions, and differentiate between cooling, refrigeration, and air conditioning. Bloom's Level: Understand (L2) **Cos2:** Describe the working of the basic refrigeration cycle and explain the functions of major components such as compressor, condenser, expansion valve, and evaporator. Bloom's Level: Understand (L2) **Cos3:** Classify and explain different types of air conditioning systems, including window, split, portable, central, and inverter ACs. Bloom's Level: Understand (L2) **Cos4:** Analyze energy consumption and evaluate the importance of energy efficiency measures such as the BEE star rating system. Bloom's Level: Analyze (L4) **Cos5:** Analyze and explain the applications of air conditioning systems in residential, commercial, and industrial sectors. Bloom's Level: Analyze (L4) **Cos6:** Apply basic techniques for installation, maintenance, and energy-saving practices in air conditioning systems. Bloom's Level: Apply (L3) Bloom's Level: Apply (L3)	
Unit 1	**Introduction to Air Conditioning**	

	Meaning and definition of air conditioning,Difference between cooling, refrigeration, and air conditioning,Importance and need of air conditioning,Basic components of an air conditioner,Concept of temperature, humidity, and human comfort conditions.,Components of air conditioning system: compressor, condenser, evaporator, expansion device ,Air distribution systems and ventilation basics	**10L**
Unit 2	**Air Conditioning Systems & Load Calculations** Types of air conditioning systems: Window AC, Split AC, Central AC Working principles of different AC systems Cooling load estimation: o Sensible heat and latent heat o Heat gain sources (walls, occupants, equipment, infiltration) Air conditioning processes on psychometric chart Duct design basics and air flow distribution Performance parameters: COP (Coefficient of Performance), EER	**10L**
Unit 3	**Energy Efficiency, Maintenance and Applications** Energy consumption in air conditioners, Energy efficiency and BEE star rating system, Energy-saving practices in AC usage, Basic installation and maintenance of AC,Applications of air conditioning in homes, offices, hospitals, malls, and industries.	**10L**
	SuggestedReadings: 1. Refrigeration and Air Conditioning – C. P. Arora 2. Publisher: Tata McGraw-Hill Education. 3. Basic Refrigeration and Air Conditioning – P. N. Anantha Narayanan 4. Publisher: Tata McGraw-Hill. 5. Principles of Refrigeration – Roy J. Dossat 6. Publisher: Pearson Education. 7. A Textbook of Refrigeration and Air Conditioning – R. S. Khurmi and J. K. Gupta	

Unit 2	**Data Movement and logical Instructions:** Move Operations: Introduction, addressing modes, external data moves, code memory read only data moves, push and pop op-codes, data exchange, simple programs, Logical operations: Introduction, byte level logical operations, bit level logical operation, rotate and swap operations, examples programs.	**10 L**
Unit 3	**Arithmetic, Jump / Call Instructions and Assembly language Programming** Arithmetic operations: Introduction, flags, instructions affecting flags, incrementing and decrementing, addition: unsigned and signed, multiple byte signed arithmetic, subtraction: Unsigned and signed subtraction, multiplication and division, decimal arithmetic, examples programs. Jump and call operations: Introduction, the jump and call program range, relative range, Short absolute range, long absolute range. Jumps, bit jumps, byte jumps, unconditional jumps, Calls and subroutine, Subroutines, Calls and the stacks, Calls and returns. Interrupts and returns, Simple programme using 8051 Microcontroller and applications.	**10L**
	Suggested Readings: 1. The 8051 Micorcontroller, Architecture, Programming and applications by Kenneth J Ayala ; Second Edition, ISBN 0-314 20188-2 (hard Copy) 1991; ISBN 0-314-77278-2(Soft) 2014. 2. Microprocessors and Interfacing : Programming and Hardware by Douglas V Hall : II Edition ; Tata McGraw-Hill Edition. 3. The 8051 Microcontroller and embedded Systems by Muhammad Ali Mazidi and Janice Gillspie Mazidi; Pearson Education.	

	SUB/ DSC/P/ 275: Practical Based on 8051 Microcontroller and Programing **(Credit: 02 Contact Hrs.: 60 Marks: 50)**	
	1. Write the Assembly level program for Data transfer from one memory location to another memory location and execute the same on 8051 kit. 2. Write the Assembly level program for Adding two 8-bit numbers and execute the same on 8051 kit. 3. Write the Assembly level program for Subtracting two 8-bit numbers and execute the same on 8051 kit. 4. Write the Assembly level program for multiplying two 8-bit numbers and execute the same on 8051 kit. 5. Write the Assembly level program for Division of two 8-bit numbers and execute the same on 8051 kit. 6. Write the Assembly level program for Division of two 8-bit numbers and execute the same on 8051 kit. 7. Write the Assembly level program to arrange the numbers in ascending order and execute the same on 8051 kit. 8. Write the Assembly level program to arrange the numbers in descending order and execute the same on 8051 kit. 9. Write an Assembly program to perform logical operations (AND, OR, XOR, NOT) on given data. 10. Write an Assembly program to perform rotate and swap operations on data.	

11. Write an Assembly program to generate time delay using timer/counter.
12. Write an Assembly program for serial data transmission and reception using 8051.

(At least eight experiments from the prescribed list of experiments should be performed successfully.)

	SUB/DSC/T/251 **Embedded System and Interfacing** **(Credits:02 Contact hours:30 Marks:50)**	
	Learning Objectives of the Course: **1.** Provide a clear understanding of the fundamentals, characteristics, and applications of embedded systems. **2.** Develop a strong foundation in microcontroller-based systems by introducing the architecture and working of the 8051 microcontroller. **3.** Introduce interfacing techniques for connecting various input/output devices such as switches, displays, sensors, and actuators with microcontrollers. **4.** Build knowledge of communication methods and peripheral interfacing including ADC, DAC, timers, interrupts, and serial communication. **5.** Equip students with practical skills to design and develop basic embedded system applications using embedded C and real-time concepts.	
	Course Outcomes (COs): **After completion of the course, students will be able to** **CO1:** Explain the fundamentals, architecture, and working of embedded systems and microcontrollers. *(Bloom's Level: Understand)* **CO2:** Demonstrate interfacing of input/output devices such as LEDs, displays, sensors, and actuators with microcontrollers. *(Bloom's Level: Apply)* **CO3:** Develop simple embedded system applications using sensors, motors, and communication interfaces. *(Bloom's Level: Apply)* **CO4:** Design basic real-time embedded systems for practical and industrial applications. *(Bloom's Level: Create)*	
Unit 1	**Interfacing Fundamentals** Introduction to interfacing **and its** importance **in microprocessor and microcontroller systems.** Basic input and output concepts **and** data transfer techniques **such as** programmed I/O, interrupt-driven I/O **and** DMA. **Understanding of** parallel communication **and** serial communication **along with their comparison.**	**10 L**

	Address decoding techniques **and their role in interfacing. Study of** memory-mapped I/O **and** I/O-mapped I/O **with comparison and applications.** Bus organization **including** data bus, address bus **and** control bus. Timing diagrams for I/O operations, handshaking techniques **and** data transfer methods.	
Unit 2	**Interfacing Techniques** Introduction to 8255 PPI **and its features.** Architecture of 8255 **including** internal block diagram **and functional description.** Pin diagram **and** signal description. Operating modes of 8255 **including** Mode 0 (Simple I/O), Mode 1 (Strobed I/O) **and** Mode 2 (Bidirectional I/O). Control word format **and** programming of 8255. Interfacing of 8255 with microprocessor/microcontroller systems **including** address decoding**. Applications such as** switch interfacing, LED interfacing, seven-segment display interfacing **and** relay interfacing.	**10 L**
Unit 3	**Embedded System Applications** Interfacing of input devices **such as** switches **and** keypads. Interfacing of output devices **including** LEDs, seven-segment displays **and** LCD interfacing. ADC interfacing, DAC interfacing **and** basic serial communication concepts. Sensor interfacing **including** temperature sensor, LDR **and** IR sensor. Actuator interfacing **such as** DC motor **and** stepper motor. PWM generation and control **techniques.** Basic embedded C concepts for interfacing **and** design of simple interfacing-based applications.	**10 L**
	Suggested Readings: 1. Embedded Systems – Raj Kamal, Tata McGraw Hill. 2. The 8051 Microcontroller – Kenneth J. Ayala. 3. Embedded Systems: Architecture, Programming and Design – K.V.K.K. Prasad. 4. ARM System Developer's Guide – Andrew Sloss.	

	SUB/ DSC/P/ 276: Practical Based on Embedded Systems and Interfaces (Credit: 02 Contact Hrs.: 60 Marks: 50)	
	1. Program to interface simple Switch and LED using 8051 microcontroller. 2. Program to interface relay and control ON/OFF operation using 8051 microcontroller. 3. Program to interface temperature sensor (LM35) and display output using 8051 microcontroller. 4. Program to interface IR sensor for object detection using 8051 microcontroller. 5. Program to control DC motor using 8051 microcontroller (with driver IC). 6. Program to interface a seven segment display using 8051 microcontroller. 7. Program for analog to digital concerter interfacing using 8051 microcontroller. 8. Program to generate Square, Ramp and Triangular waves using DAC interface to 8051 microcontroller.. 9. Program for interfacing stepper motor with 8051 microcontroller.	

	10. Program to interface an LCD using 8051 microcontroller. 11. Program to interface Matrix keyboard using 8051 microcontroller. **(At least Eight experiments from the prescribed list of experiments should be performed successfully.)**	

	SUB/Mn/T/250 **Renewable Energy Sources** **(Credits:02 Contact hours:30 Marks:50)**	
	Learning Objectives of the Course: 1. Provide a clear understanding of the fundamentals of renewable energy and its role in sustainable development. (Understand) 2. Explain the working principles of major renewable energy sources such as solar, wind, biomass, and hydro. (Understand) 3. Analyze different energy conversion technologies and their operational mechanisms. (Analyze) 4. Evaluate the environmental and economic impacts of renewable energy systems. (Evaluate) 5. Apply renewable energy concepts to real-world energy challenges and system design. (Apply)	
	Course Outcomes (COs): **After completion of this course, students will be able to:** **CO1:** Describe various renewable energy sources and their significance in the global energy scenario. (Bloom's Level: Understand) **CO2:** Explain the working principles and technologies of solar, wind, biomass, and hydro energy systems. (Bloom's Level: Understand) **CO3:** Analyze the performance and efficiency of different renewable energy conversion systems. (Bloom's Level: Analyze) **CO4:** Evaluate environmental and economic aspects of renewable energy technologies. (Bloom's Level: Evaluate) **CO5:** Apply knowledge of renewable energy systems to solve practical energy-related problems. (Bloom's Level: Apply)	
Unit 1	**Solar and Wind Energy Systems** Introduction to renewable energy, energy scenario and need for renewable sources, solar radiation and its measurement, solar thermal systems, solar photovoltaic systems, working principles and applications, wind energy basics, wind resource assessment, wind turbines and their types, performance and applications.	**10 L**
Unit 2	**Biomass and Hydro Energy** Biomass energy sources, classification and conversion techniques, biogas production and utilization, biofuels, environmental impact of biomass energy, hydropower fundamentals, types of hydroelectric plants, micro and mini hydel systems, advantages and limitations of hydro energy.	**10 L**

Unit 3	**Emerging Renewable Technologies and Energy Storage** Geothermal energy, tidal and wave energy, hydrogen energy and fuel cells, energy storage systems (batteries, supercapacitors), hybrid energy systems, grid integration, environmental and economic aspects of renewable energy technologies.	**10 L**
	Suggested Readings: 1. B. H. Khan, Non-Conventional Energy Resources 2. G. D. Rai, Non-Conventional Energy Sources 3. Twidell& Weir, Renewable Energy Resources 4. John W. Twidell and Tony Weir, Renewable Energy Resources (2nd Edition)	

	SUB/Mn/T/251 **Fundamentals of Solar Energy Systems** **(Credits:02 Contact hours:30 Marks:50)**	
	Learning Objectives of the Course: 1. Recall fundamental concepts of solar energy and solar radiation. (Remember) 2. Explain the principles of solar radiation and energy conversion technologies. (Understand) 3. Apply solar energy concepts in basic calculations and system design. (Apply) 4. Analyze the performance and efficiency of solar thermal and photovoltaic systems. (Analyze) 5. Evaluate different solar energy systems based on technical, environmental, and economic factors. (Evaluate) 6. Design solar energy-based solutions for real-world applications. (Create)	
	Course Outcomes (COs): **After completion of this course, students will be able to:** **CO1:** Recall and describe the basic concepts of solar radiation and measurement techniques. *(Bloom's Level: Remember / Understand)* **CO2:** Explain the working principles of solar thermal and photovoltaic systems. *(Bloom's Level: Understand)* **CO3:** Apply solar energy principles for performance calculations and basic system design. *(Bloom's Level: Apply)* **CO4:** Analyze the efficiency and operational characteristics of solar energy devices. *(Bloom's Level: Analyze)* **CO5:** Evaluate solar energy systems based on performance, cost, and environmental impact. *(Bloom's Level: Evaluate)* **CO6:** Design and propose solar energy solutions for practical applications. *(Bloom's Level: Create)*	
Unit 1	**Solar Radiation and Measurement** Introduction to solar energy, solar constant, solar radiation geometry, solar angles, measurement of solar radiation, instruments for radiation measurement, estimation of solar radiation, basic concepts of heat transfer in solar systems.	**10 L**
Unit 2	**Solar Thermal Systems** Principles of solar thermal energy conversion, flat plate collectors, evacuated tube collectors, concentrating collectors, solar water heating systems, solar cookers, solar dryers, performance analysis and efficiency of thermal systems.	**10 L**
Unit 3	**Solar Photovoltaic Systems** Photovoltaic effect, types of solar cells, construction and working of PV cells, characteristics of solar panels, PV system components, stand-alone and grid-	**10 L**

	connected systems, applications of solar PV, basics of energy storage in solar systems.	
	Suggested Readings: 1. S. P. Sukhatme and J. K. Nayak, Solar Energy: Principles of Thermal Collection and Storage 2. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications 3. Duffie and Beckman, Solar Engineering of Thermal ProcessesB. H. Khan, Non-Conventional Energy Resources	

SUB/ SEC/P/ 275: Practical Based on Inverter-II
(Credit: 02 Contact Hrs.: 60 Marks: 50)

Course Objectives:

- To Develop a clear understanding of three-phase inverters and the basic principles of DC to AC conversion in multi-phase systems.
- Understand the circuit configuration, switching sequence, and operation of three-phase bridge inverters using IGBT and recognize their advantages in power electronics applications.
- Gain knowledge of PWM techniques, especially Sinusoidal PWM (SPWM), for controlling inverter output and improving waveform quality.
- Understand the concept of harmonics, Total Harmonic Distortion (THD), and methods to reduce harmonics in inverter systems.
- Develop the ability to analyze inverter performance under different load conditions and understand practical applications such as motor drives (VFD) and solar inverters

Course Outcomes:

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

1. Explain the principles of three-phase inverters, including circuit configuration, switching sequence, and output waveforms.
   Bloom's Level: Understand (L2)
2. Analyze the performance and advantages of switching devices like IGBT in inverter circuits.
   Bloom's Level: Analyze (L4)
3. Explain and apply PWM techniques, especially SPWM, for controlling inverter output.
   Bloom's Level: Apply (L3)
4. Analyze harmonics in inverter outputs, calculate THD, and suggest methods for harmonic reduction.
   Bloom's Level: Analyze (L4)
5. Evaluate inverter performance under different load conditions and explain applications such as motor drives and solar inverters.
   Bloom's Level: Analyze (L4)

	1. Sinusoidal PWM (SPWM) Inverter 2. Harmonic Analysis of Inverter Output 3. Measurement of Total Harmonic Distortion (THD) 4. Load Analysis of Inverter (R and RL Load) 5. Speed Control of Induction Motor using Inverter 6. Study of Solar Inverter (Off-Grid) 7. Study of Series Inverter Circuits 8. Study of Three Phase Inverter using IGBT 9. Study of Parallel inverter Circuits 10. Voltage Commutated Inverter 11. Speed Control of Induction Motor using Inverter 12. Load Analysis of Inverter with Resistive (R) Load **(At least Ten experiments from the prescribed list of experiments Should be performed successfully.)**	
	SUB/SEC/ P/ 275: Inverter-II **(Theoretical foundations of the experiments shall be acquired through self-study)**	
Unit 1	**Three-Phase Inverters and Switching Devices** Introduction to Three-Phase Inverters, Basic principle of DC to AC conversion in three-phase systems, Three-Phase Bridge Inverter using IGBT-Circuit configuration, Switching sequence, Output voltage waveforms, Advantages of IGBT in inverter circuits, Applications of three-phase inverters	
Unit 2	**PWM Techniques and Harmonic Analysis** Introduction to Pulse Width Modulation (PWM), Sinusoidal PWM (SPWM) Inverter- Principle of SPWM, Carrier and reference signals, Output waveform characteristics, Harmonics in Inverter Output- Sources of harmonics, Effects of harmonics on power systems, Total Harmonic Distortion (THD)- Definition and formula, Measurement Methods, Techniques for harmonic reduction	
Unit 3	**Inverter Performance, Applications and Simulation** Load Analysis of Inverter-Resistive (R) load, Inductive (RL) load, and Effect on output waveform, Speed Control of Induction Motor using Inverter, Basic principle of variable frequency drive (VFD), Frequency control method, Solar Inverter (Off-Grid)-Basic block diagram, Working principle and applications, Design and Simulation of SPWM Inverter Introduction to MATLAB / Proteus,Basic steps of inverter simulation, Advantages of simulation in power electronics	
	Suggested Readings: 1. M.H. Rashid – Power Electronics: Circuits, Devices and Applications 2. P.S. Bimbhra – Power Electronics 3. Ned Mohan – Power Electronics: Converters, Applications and Design 4. V.K. Mehta & Rohit Mehta – Principles of Power Electronics	

	SUB/ SEC/P/ 276: Arduino Programming and Interfacing (Credit: 02 Contact Hrs.: 60 Marks: 50)	
	Course Objectives: 1. To understand the **basics of Arduino UNO**, **Arduino IDE**, and **communication protocols**. 2. To develop skills in **Arduino programming** using **basic constructs and functions**. 3. To apply **digital and analog I/O operations** in practical applications. 4. To perform **interfacing of input/output devices, sensors, and actuators**. 5. To design simple **Arduino-based embedded system applications**.	
	Course Outcomes (COs): After completion of the course, students will be able to: **CO1:** Explain the features of Arduino UNO, Arduino IDE, and communication protocols such as SPI and I2C. (Understand – L2) **CO2:** Describe and implement basic Arduino programming structure including setup(), loop(), variables, constants, and control statements. (Apply – L3) **CO3:** Apply digital and analog I/O functions such as digital Read(), digital Write(), analog Read(), analog Write(), and map() in practical applications. (Apply – L3) **CO4:** Interface and program input and output devices such as push-buttons, LEDs, potentiometers, seven-segment displays, and LCDs. (Apply – L3) **CO5:** Analyze and implement sensor and actuator interfacing including DHT11, LDR, DC motor, relay, and servo motor. (Analyze – L4) **CO6:** Design and develop real-time Arduino-based applications such as plant watering system, weather monitoring system, and obstacle detection system. (Create – L6)	
	1. To interface a push-button and an LED with the Arduino UNO and monitor the input/output states using the Serial Monitor. 2. To read analog values from a potentiometer, scale the data using the map () function, and control the brightness of an LED using Pulse Width Modulation (PWM). 3. To interface a DHT11 temperature sensor with the Arduino and display the real-time environmental data on Serial Monitor. 4. To interface a DHT11 humidity sensor with the Arduino and display the real-time environmental data on Serial Monitor. 5. To control an AC light using the Arduino UNO and an electromechanical relay module based on LDR input. 6. Arduino-Based Plant Watering System. 7. Arduino-Based Weather Monitoring System. 8. Arduino-Based Obstacle Detection and Warning System. 9. Interfacing Servomotor with Arduino UNO 10. Interfacing Relay with Arduino UNO 11. Interfacing 16x2 LCD display with Arduino 12. Interfacing multi-digit seven-segment display with Arduino **(At least Ten experiments from the prescribed list of experiments should be performed successfully.)**	

	SUB/SEC/ P/ 276: Arduino Programming and Interfacing (Theoretical foundations of the experiments shall be acquired through self-study)	
Unit 1	**Introduction to Arduino UNO Board and the IDE** Features of Arduino UNO Board; Arduino IDE Software: Editor, Compiler, Linker, Locator, Hex Converter, Loader; Arduino IDE Download; Working with Arduino IDE; Introduction to ATmega 328; Serial Peripheral Interface (SPI) Communication Protocol: Steps of SPI Data Transmission, Advantages of SPI Data Transmission, Disadvantages of SPI Data Transmission; Inter-Integrated Circuit (I2C) Communication Protocol.	**10 L**
Unit 2	**Arduino Programming Constructs** Structure of Arduino Programming: Setup (), Loop (), Variables, Constant, Integer; Function: pinMode(pin, mode), digitalWrite(pin, value), digitalRead(pin), analogRead (pin), analogWrite(pin, value), delay(value), for loop, Serial. begin(rate), Serial.print("argument"), Serial.Println("argument"); if statement: Simple if, if/else, Multiple if/else; map function.	**10 L**
Unit 3	**Interfacing and Programming with Arduino** LED Interfacing and Programming; Display in Serial Monitor; Push-Button Interfacing and Programming; Seven-Segment Display Interfacing and Programming; Potentiometer Interfacing and Programming; Interfacing and Programming of Arduino with Humidity and Temperature Sensor DHT11; LCD Interfacing and Programming; Interfacing and Programming of Arduino with DC Motor; Interfacing and Programming of Arduino with High-Voltage Device and Relay; Interfacing and Programming of Arduino UNO with Light-Dependent Resistor (LDR).	**10 L**
	SuggestedReadings: 1. https://www.arduino.cc/ 2. Misra, Y. Programming and Interfacing with Arduino. CRC Press. 3. Margolis, M., Jepson, B., & Weldin, N. R. Arduino Cookbook. O' Reilly Media. 4. Blum, J. Exploring Arduino: Tools and Techniques for Engineering Wizardry. Wiley.	

	GE/OE-4: Introduction to Refrigeration (Credit: 02 Contact Hrs.:30 Marks: 50) This course will be available for the undergraduate students from the Faculty of Humanities and Faculty of Commerce and Management with no prior background in electronics or engineering	
	Learning Objectives of the Course: 1. Provide a clear understanding of the fundamental principles, need, and applications of refrigeration systems. 2. Develop knowledge of different refrigeration cycles and working fluids by introducing vapour compression and vapour absorption systems. 3. Introduce the components of refrigeration systems such as compressors, condensers, evaporators, and expansion devices along with their working. 4. Build analytical skills to evaluate the performance of refrigeration systems and factors affecting efficiency. 5. Equip students with the ability to apply refrigeration concepts in domestic, industrial, and eco-friendly applications.	
	Course Outcomes **After completion of the course, students will be able to:** **CO1:** Explain the basic principles, terminology, and working of refrigeration systems. *(Bloom's Level: Understand)* **CO2:** Describe different refrigeration cycles, refrigerants, and system components. *(Bloom's Level: Understand)* **CO3:** Analyze the performance of refrigeration systems using parameters such as COP and efficiency. *(Bloom's Level: Analyze)* **CO4:** Apply refrigeration concepts to real-life applications including domestic, industrial, and modern eco-friendly systems. *(Bloom's Level: Apply)*	
	Unit 1: Fundamentals of Refrigeration Introduction to refrigeration, need and applications of refrigeration, basic principles of refrigeration, refrigeration effect, units of refrigeration (Ton of Refrigeration), reversed Carnot Cycle, Vapour Compression Refrigeration Cycle (basic concept), coefficient of performance (COP), basic thermodynamic processes involved, properties of refrigerants, classification of refrigerants, environmental impacts (ODP, GWP).	**10L**
	Unit 2: Refrigeration Systems and Components Vapour compression refrigeration system: working and components (compressor, condenser, expansion valve, evaporator), types of compressors, condensers and evaporators, Vapour Absorption Refrigeration System, comparison between VCR and VAR systems, refrigerant flow control devices, safety devices and controls in refrigeration systems.	**10L**

	Unit 3: Performance Analysis and Applications Performance analysis of refrigeration systems, factors affecting system performance, methods of improving COP, multi-stage and cascade refrigeration systems (basic idea), applications of refrigeration in domestic refrigerators, air conditioning systems, cold storage, food preservation, and industrial applications, introduction to eco-friendly and modern refrigeration techniques.	**10L**
	SuggestedReadings: 1. Refrigeration and Air Conditioning by C. P. Arora 2. Refrigeration and Air Conditioning by R. S. Khurmi, J. K. Gupta 3. A Course in Refrigeration and Air Conditioning by S. C. Arora, S. Domkundwar 4. Principles of Refrigeration by Roy J. Dossat 5. Basic Refrigeration and Air Conditioning byP. N. Anantha Narayanan	

Semester - IV

	SUB/DSC/T/250 **8051 Microcontroller and Programming** **(Credits:02 Contact hours:30 Marks:50)**	
	Course Objectives: 1. **Provide a clear and comprehensive overview** of the differences between microprocessors and microcontrollers. 2. **Develop a strong understanding** of the fundamental concepts and architecture of the 8051 microcontroller. 3. **Introduce the internal structure** of the 8051, including its registers, I/O ports, memory organization, and addressing modes. 4. **Build foundational knowledge** of arithmetic operations, instruction sets, and jump ranges in the 8051 microcontroller. 5. **Equip learners with practical skills** in assembly language programming for the 8051 microcontroller.	
	Course Outcomes (COs): **After completing this course, students will be able to:** **CO1: Describe and differentiate** between microprocessors and microcontrollers. (Bloom's Level: Understand) **CO2: Explain the architecture and functional blocks** of the 8051 microcontroller. (Bloom's Level: Understand) **CO3: Demonstrate the use of programming tools** for developing applications using the 8051 microcontroller. (Bloom's Level: Apply) **CO4: Develop and analyze assembly language programs** for the 8051 microcontroller. (Bloom's Level: Apply / Analyze)	
Unit 1	**8051 Microcontroller** An Introduction: Microprocessors and Microcontrollers, comparing microprocessors and Microcontrollers, a Microcontrollers survey, development system for Microcontrollers, 8051 Microcontroller hardware: Block diagram, Programming model, pin configuration, the 8051 oscillator and clock, program counter and data pointer, A and B CPU registers, flags and program status word, internal memory, internal RAM, the stack and the stack pointer, special function registers, internal ROM; Input / output pins, ports and circuits: port pin circuits, port 0, port 1, port 2, port 3; memory organization, counters and timers, serial data input / outputs, interrupts.	**10 L**