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SOLAR TECHNOLOGY AND MAINTENANCE **Course Code : 316374**

Programme Name/s	**: Automation and Robotics/ Digital Electronics/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electronics & Communication Engg./ Electronics Engineering/ Industrial Electronics/ Electronics & Computer Engg./**
Programme Code	**: AO/ DE/ EJ/ EK/ ET/ EX/ IE/ TE**
Semester	**: Sixth**
Course Title	**: SOLAR TECHNOLOGY AND MAINTENANCE**
Course Code	**: 316374**

I. RATIONALE

The course "Solar PV Technology and Maintenance" is designed to meet the growing demand for skilled technicians in the solar and electronics industries. It provides students with knowledge of solar PV fundamentals, electronic components, charge controllers, inverters, IoT-based monitoring, and battery management systems used in solar applications. The course emphasizes practical skills in installation, testing, commissioning, troubleshooting, and maintenance of solar PV systems using modern electronic instruments and monitoring tools. Safety practices, diagnostic techniques, and preventive maintenance procedures are integral parts of the curriculum. On completion, students will be capable of supporting smart and sustainable solar energy systems in the renewable energy sector.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry/employer expected outcome through various teaching learning experiences: 'Install and maintain solar PV system.'

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Apply solar PV fundamentals for installation and commissioning of solar system.
- CO2 - Select appropriate electrical components for solar PV system.
- CO3 - Install and commission solar PV systems as per relevant safety standards.
- CO4 - Maintain the solar PV batteries.
- CO5 - Carry out maintenance and safety practices of solar PV systems.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316374	SOLAR TECHNOLOGY AND MAINTENANCE	SOL	DSE	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

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Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Classify the given energy sources. TLO 1.2 Apply basics of solar energy in design of solar system. TLO 1.3 Calculate output power of a solar cell based on given data. TLO 1.4 Estimate the number of PV modules to be connected in order to design a solar PV system for power generation for given requirement. TLO 1.5 Distinguish between given types of solar PV systems.	**Unit - I Fundamentals of Solar Energy and PV Systems** 1.1 Energy Sources and Need of Solar Energy: Classification of energy sources: renewable and non-renewable, Advantages of solar energy over conventional sources, Role of MNRE in solar energy development in India. 1.2 Basics of Solar Energy: Solar radiation: Solar spectrum, extraterrestrial radiation, radiation on the earth surface. Terms related to solar radiation-radiation, irradiation, insolation, beam radiation; diffuse radiation, Solar constant, solar radiation at a given location, annual radiation in solar radiation, optimal tilt for solar equipment, monthly averaged global radiation at optimal tilt. 1.3 Fundamentals of PV Cell: Significance and meaning of Solar Cell, Solar Cell principle of Electricity Generation. Parameters of solar Cell and their units. (Numerical based on this topic). Commercial solar cell technology, materials, and their efficiency. Factors affecting electricity generated by a solar cell- • Effect of conversion efficiency • Change in the amount of Input Light • Change in the solar cell area • Change in angle of light falling on solar cell • Change in solar cell operating temperature. Basic characteristics of semiconductor devices used in solar PV systems I-V and P-V characteristics of solar cells using electronic measuring instruments 1.4 PV Module, Array and Standards: Meaning of Solar PV Module, Ratings of PV Module, Standard PV module parameters, (Numerical based on this topic), Measurement of Voc and Isc. Bypass Diode, Blocking Diode. Connection of Solar PV modules in series, parallel and series-parallel. 1.5 Types of Solar PV Systems: Standalone Solar PV system and Grid connected SPV system. Block diagram and description of Grid connected SPV system without battery storage/Back-up, Grid connected SPV system with battery storage/Back-up.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Hands-on

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Classify power converters. TLO 2.2 Compare given types of inverters on given points. TLO 2.3 Choose appropriate inverter based on given data. TLO 2.4 Choose appropriate given charge controller based on given data. TLO 2.5 .Select appropriate electrical components for solar PV system. TLO 2.6 Draw wiring diagram of connection of a given meter	**Unit - II Balance of System (BoS)** 2.1 Introduction: Need of Balance of System (BoS), Components of BoS. Power converters and their efficiency. Importance of efficiency of power converters. Classification of power converters. 2.2 Inverters (DC to AC Converters): Inverter-Concept, types- Voltage Source Inverter (VSI) and Current Source Inverter (CSI). Comparison of VSI and CSI. Circuit diagram working and output waveform of Half-bridge and full-bridge VSI. Pulse width modulation: need, types: Sinusoidal Pulse Width Modulation (SPWM), Multiple Pulse Width Modulation (MPWM). SPWM: concept, working principle and waveforms. 2.3 Types of Solar Inverters: Standalone inverters or Off-grid inverter, Grid-tie inverters or grid-interactive inverter, Battery back-up grid-tie inverter; their applications. Inverter specifications and efficiency. Selection of inverter based on load. Introduction to smart inverters. 2.4 Charge Controllers • Function, working and features of a charge controller. Terminologies related to charge controller. Commonly used set points and their behaviour in charge controller. • Types of charge controllers: Serries, Parallel, Discharge, Combined charge and discharge • Charge Controller Technologies: PWM and MPTT. Typical specifications, Selection based on load, Power output from a PV Module • Need for Maximum Power Point Tracking • Comparison of PWM and MPPT charge controllers • Use of sensors and microcontroller-based control in MPPT systems 2.5 Electrical Components • AC and DC cables, selection and sizing, materials • MC4 connectors • AC DP, DC DP, MCB, ELCB, switchgear • Earthing requirements in PV solar system • Electronic testing instruments used in PV systems: multimeter, clamp meter, insulation tester. 2.6 Metering, IoT and Warranty: Energy meter, generation meter, net metering- connections and wiring diagram. IoT-based monitoring. Warranty: component-level and performance-level.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Site/Industry Visit

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Perform feasibility study for rooftop solar PV installation. TLO 3.2 Estimate the number of modules and inverter capacity based on given data. TLO 3.3 Select mechanical components for installation. TLO 3.4 Describe the procedure for electrical installation and grid interfacing. TLO 3.5 Prepare documents for commissioning.	**Unit - III Installation and Commissioning of Solar PV Systems** 3.1 Load Assessment and Site Survey: Estimation of electrical load. Interpretation of electricity bill (connected load, sanctioned load, units consumed). Assessment of daily energy requirement. Site selection criteria for rooftop solar PV system. Roof inspection: type of roof, available shadow-free area, orientation and tilt. Shadow analysis and its effect on system performance. Feasibility study for rooftop solar PV installation. 3.2 System Layout, Design and Planning: Preparation of system layout for rooftop solar PV system. Selection of system configuration (grid-connected / off-grid / hybrid). Single line diagram (SLD) of rooftop solar PV system. Mechanical layout planning. Selection and sizing of solar PV modules, inverter and balance of system components. Estimation of number of modules and inverter capacity. 3.3 Mechanical Installation of Solar PV System • Types of mounting structures: fixed tilt and adjustable tilt • Selection of mounting structure material • Installation procedure of rooftop mounting structure • Module mounting on structure with proper orientation and tilt angle • Spacing between modules and rows • Safety precautions during mechanical installation • Installation of sensor modules for weather and performance monitoring • Cable management practices for power and signal cables 3.4 Electrical Installation and Grid Interfacing • Formation of series, parallel and series-parallel PV strings • DC cabling: routing, dressing and protection • Installation of DCDB, ACDB and inverter • Installation of generation meter and net meter • Grid synchronization • Wiring and interfacing of monitoring systems, sensors and communication devices • Testing continuity, polarity, insulation resistance and earthing using electronic test instruments • Introduction to remote monitoring and data acquisition systems 3.5 Commissioning and Safety Practices • Commissioning procedure of rooftop solar PV system • Documentation and commissioning checklist • Safety practices during installation and commissioning • Performance verification and troubleshooting during commissioning • Electrical and electronic safety standards applicable to rooftop solar PV systems	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Site/Industry Visit

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Design the battery system from given data. TLO 4.2 Describe the procedure to detect given fault in battery. TLO 4.3 Describe the given instrument/tool used in battery maintenance.	**Unit - IV Application of Batteries** 4.1 Basics of Batteries • Types of Batteries • Parameters of batteries • Batteries for PV system: Liquid vented, Sealed or VRLA (Valve Regulated Lead-acid) • Lithium-ion batteries for solar PV applications • Series and parallel connection of batteries • Estimation of number of batteries to be connected in mixed connection • Battery charging and discharging characteristics • Battery Management System (BMS): functions and applications • Measurement of battery parameters using electronic measuring instruments 4.2 Battery Bank Installation & Commissioning • Steps involved for replacement of old batteries and new installation • Inspection of batteries before testing • Battery diagnostics test and battery fault detection • Installation procedure for battery bank connections and protection devices • Testing of battery voltage, current and internal resistance • Monitoring of battery bank using digital controllers and IoT-based systems • Safety precautions during battery installation and commissioning 4.3 Maintenance of Batteries • Physical maintenance: Cleaning of contact terminals and specific gravity observation • Instruments and tools required for maintenance • Safety measures • Do's and Don'ts for batteries • Preventive maintenance of battery bank and charging system • Troubleshooting of battery-related faults in solar PV systems • Disposal and recycling practices for used batteries • Monitoring battery health using electronic monitoring devices	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Compare given types of maintenance. TLO 5.2 Prepare given type of maintenance schedule. TLO 5.3 Describe the procedure of maintenance of given component. TLO 5.4 Identify possible defects from infrared images.	**Unit - V Maintenance of PV System** 5.1 Types of Maintenance • Preventive maintenance • Breakdown maintenance • Predictive maintenance • Corrective maintenance • Importance of maintenance for reliable operation of solar PV systems 5.2 Panel Cleaning, Safety & Maintenance • Panel cleaning methods and protocols • Precautions during cleaning • Work-at-height safety • SPV maintenance protocols • Daily and monthly maintenance schedule • Maintenance checklist preparation • Use of sensors and IoT devices for monitoring panel performance and environmental conditions • Personal protective equipment (PPE) and electrical safety practices during maintenance 5.3 Component-wise Maintenance • Troubleshooting and maintenance of Inverter • Junction box and DC array inspection • PV module maintenance • Inspection and maintenance of cables, connectors, protection devices and earthing system • Testing of electrical and electronic components using multi-meter, clamp meter and insulation tester • Monitoring, troubleshooting and maintenance of charge controller. 5.4 Thermography • Meaning of thermography • Common application of thermography • Advantages of thermographic solar panel testing • Infrared images and possible defects • Identification of hotspots, loose connections and faulty cells using thermal imaging • Use of thermal cameras and digital diagnostic tools in PV system maintenance • Interpretation of thermographic reports for fault analysis and preventive maintenance	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Measure open circuit voltage (Voc) and short circuit current (Isc) of a PV module. LLO 1.2 Plot I–V and P–V characteristics. LLO 1.3 Find various parameters.	1	I V and P V Characteristics of PV module .*	2	CO1
LLO 2.1 Measure output voltage and current of a solar cell under different illumination conditions. LLO 2.2 Analyse the effect of light intensity and angle on solar panel output. LLO 2.3 Analyse the effect of shadow on solar panel output. LLO 2.4 Analyse the effect of temperature on solar panel output.	2	Effect of Illumination and temperature on output of PV cell module.	2	CO1
LLO 3.1 Connect PV modules in series, parallel and series-parallel combinations. LLO 3.2 Measure output voltage, current and power. LLO 3.3 Estimate number of modules required for given load.	3	Series and Parallel Connection of PV Modules *	2	CO1

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Analyse given load details. LLO 4.2 Calculate total connected load and power rating. LLO 4.3 Select suitable inverter based on specifications.	4	Selection of Inverter Based on Load Requirement *	2	CO2
LLO 5.1 Calculate PV module output power. LLO 5.2 Select suitable PWM / MPPT charge controller based on ratings.	5	Selection of Charge Controller for Given Load.	2	CO2
LLO 6.1 Identify AC and DC cables, MC4 connectors. LLO 6.2 Identify AC DP, DC DP, MCB, ELCB and earthing arrangement. LLO 6.3 Select cable size for given current rating.	6	Cable Selection, Protection Devices and Earthing *	2	CO2
LLO 7.1 Calculate average daily consumption based on yearly electricity bills. LLO 7.2 Estimate the size of solar PV system. LLO 7.3 Perform site survey. LLO 7.4 Draw single line diagram for solar rooftop system.	7	Load assessment and site survey	2	CO3
LLO 8.1 Identify different components of solar PV mounting. LLO 8.2 Perform Marking base of pillar mount on roof top. LLO 8.3 Perform Drilling on rooftop for pillar mount base and fix the pillars on rooftop. LLO 8.4 Assemble remaining components on the pillar mounts on rooftop.	8	Installation of a solar PV mounting *	2	CO3
LLO 9.1 Identify various fittings for mounting solar panels. LLO 9.2 Identify the connector. LLO 9.3 Crimp male and female connector, connect and test connectivity.	9	Identification of fittings for mounting solar panels and cable connectors *	2	CO3
LLO 10.1 Calculate daily energy requirement. LLO 10.2 Estimate number of batteries required in series-parallel (mixed) connection. LLO 10.3 Prepare battery bank configuration.	10	Estimation of Number of Batteries for Given Load *	2	CO4
LLO 11.1 Identify tools and instruments used for battery maintenance. LLO 11.2 Perform physical maintenance such as cleaning of terminals. LLO 11.3 Measure specific gravity of electrolyte.	11	Maintenance of Batteries	2	CO4
LLO 12.1 Perform panel cleaning using dry and wet methods. LLO 12.2 Follow standard cleaning protocols. LLO 12.3 Follow precautions during cleaning.	12	Panel Cleaning and Maintenance Procedure	2	CO5
LLO 13.1 Prepare daily and monthly maintenance checklist. LLO 13.2 Develop a basic maintenance schedule for a rooftop solar PV system. LLO 13.3 Record inspection observations.	13	Preparation of Maintenance Checklist and Schedule	2	CO5

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 14.1 Inspect inverter for faults and warning indications. LLO 14.2 Inspect junction box and DC array connections. LLO 14.3 Perform visual inspection of PV modules.	14	Component-wise Maintenance of Solar PV System*	2	CO5
LLO 15.1 Analyse infrared images of solar PV modules. LLO 15.2 Identify common defects from infrared images.	15	Application of thermography in fault detection	2	CO5
LLO 16.1 Analyse the street light load and calculate daily energy requirement. LLO 16.2 Estimate the required solar PV module capacity for the street light system. LLO 16.3 Determine suitable battery capacity and configuration for the system. LLO 16.4 Prepare the list of all components required.	16	Estimation of Solar Street Light System *	2	CO2 CO3

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Develop a kit to demonstrate series, parallel, and series-parallel connections and observe output variation. (Group activity)
- Design and assemble a kit to demonstrate measurement of voltage, current, and power of a PV module. (Group activity)
- Fabricate a working model consisting of PV module, battery, charge controller, and LED lamp. (Group activity)
- Fabricate a kit to demonstrate battery charging using solar energy with voltage and current indication. (Group activity)
- Develop a kit showing DC MCB, fuse, earthing, and surge protection used in solar PV systems. (Group activity)

Industrial Visit (Compulsory)

- Observe the overall layout and working of a 1 kW rooftop grid-connected solar PV plant by identifying major components, studying module orientation and mounting, examining inverter operation, metering and grid synchronization, and noting safety and earthing practices. Record real-time power generation, understand basic operation and maintenance procedures, and prepare a structured industrial visit report highlighting system performance and learning outcomes.

Assignment

- Prepare an estimate for one Roof top Solar System of 3 or 5 KW
- Prepare a detailed report on PV modules, inverter, charge controller, batteries, and protection devices with specifications.
- Perform comparative study of on-grid, off-grid, and hybrid solar PV systems with neat block diagrams and applications.
- Prepare report on electrical and work-at-height safety practices followed during installation and maintenance.

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- Prepare a report on net metering concepts, metering arrangement, billing mechanism, and regulatory provisions for rooftop solar PV systems.
- Identify, study, and compare 5/10/15 original Equipment manufacturers' products - solar PV modules, Inverters, and other key equipment and compare them for Technology, technical specifications, prices etc.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	IV Curve Tester for PV modules All-in-one PV system test solution , IEC 62446-1 standards for Category 1 and Category 2 tests Open-circuit voltage (VOC) measurement at the PV module/string up to 1000 V DC Short-circuit (ISC) current measurement at the PV module/string up to 20 A DC On-location I-V curve results compares manufacturer I-V curve data to measured data on the analyzer screen, accurately measures modules with an efficiency of up to approximately 19% or equivalent specifications	1
2	Solar Cell Demonstration Kit	1
3	Solar simulator for Solar Cell Characteristics Study	1,2
4	Digital Multimeter 3 and 1/2 Digit	1,2
5	Digital Clamp on meter	1,2
6	Different types of solar panel as per required rating , PV Panel Polycrystalline , mono crystalline , Mono PERC , N type TOP con , Bifacial < HJT of suitable Wp size solar panel	1,2,3,4
7	500 W or 1 KW on grid PV solar system with metring and protection circuits	1,2,3,4,5,6,8,14
8	Thermography camera for solar inspections 160 X 120 IR resolution, thermal sensitivity of < 100mK (0.1 degree C) and a temperature range of -20 degree C to 150 degree C with MSK image blending technology	15
9	Lux meter	2
10	Pyranometer	2
11	Irradiance meter	2
12	500 Wats or 1KW off grid solar system with battery. , adjustable mounting system to change panel angle , Protection circuits	2,4,5,6,8,9,10,11,12,15
13	Solar Grid Tied Inverter Demonstration Kit Single phase Grid tie 1 KW / 2 KW/ 3 KW / 4 KW /5 KW model . MPPT input rangematching PV cell array , Efficiency grater than 96 % Anti islanding protection , Hybrid varsion for battery integration	4
14	Charge Controller PWM MPPT type	5
15	DC Isolator Rated Voltage :1000 V DC (> = array Voc) ; Rated Current 32 A (>= array Isc) ; 2 Pole type IP 65 enclosure	6,8
16	AC Isolator / MCB Rated Voltage 230 V AC (Single Phase) Rated Current 20 -25 A (As per inverter output Current 2 pole type IP 65 Enclosure	6,8
17	DC Cables PV Graded DC Cables (Copper conductors)	6,8

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Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
18	Earthing and SPD Lightening Surge protection and earthing kit	6,8
19	Mounting Structure Aluminium rails , Clamps , anchor bolts , flashing for roofs penetration	6,8
20	DC combiner Box for >1 string with fuses and protection string	6,8
21	Energy meter Bidirectional meter For net metering as per utility requirement	6,8
22	Panel for Solar Energy Trainer with Grouping of Solar Cell	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of Solar Energy and PV Systems	CO1	14	6	4	6	16
2	II	Balance of System (BoS)	CO2	14	2	8	6	16
3	III	Installation and Commissioning of Solar PV Systems	CO3	14	2	4	10	16
4	IV	Application of Batteries	CO4	8	2	4	4	10
5	V	Maintenance of PV System	CO5	10	2	4	6	12
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests, each worth 30 marks, will be conducted, and the average of the two tests will be considered. For formative assessment of laboratory learning 25 marks: Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment. and the average of all practical will be considered.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning. End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	1	2	2	1	2			
CO2	3	1	1	3	2	1	2			
CO3	3	2	2	2	2	2	2			
CO4	3	1	1	2	1	1	2			
CO5	3	1	1	3	2	1	2			

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Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Chetan Singh Solanki	Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers, and Engineers	PHI Learning Pvt. Ltd., 2016, ISBN 13: 978?81?203?4711?3
2	D. P. Kothari, K. C. Singal	Renewable Energy Sources and Emerging Technologies	PHI Learning Pvt. Ltd., 2022, ISBN 13: 978-81-203-4470-9
3	Chetan Singh Solanki	Renewable Energy Technologies- A Practical guide for beginners	PHI Learning Pvt. Ltd., 2008, ISBN 13: 978-81-203-3434-2
4	Chetan Singh Solanki	Solar Photovoltaics: Fundamentals, Technologies and Applications	PHI Learning Pvt. Ltd., 2015, ISBN 13: 978-81-203-5111-0

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://eerem.delhi.gov.in/sites/default/files/eerem/important-news/faqs_on_grid_connected_rooftop_solar_pv_system.pdf	FAQ on grid connected rooftop solar PV system
2	https://aeda.assam.gov.in/sites/default/files/swf_utility_folder/departments/aeda_snt_uneecopscloud_com_oid_5/latest/sop_gcpv_installation_c.pdf	Installation of Grid Connected Rooftop Solar Photovoltaic Systems
3	https://dgt.gov.in/sites/default/files/2024-08/Rooftop_book.pdf	Rooftop Solar PV (Installation & Maintenance) Book
4	https://cleanenergybusinesscouncil.com/solar-energy-glossary/thermography-in-pv/#IV_What_are_the_common_applications_of_Thermography_in_PV	Basics of Thermography
5	https://www.murcal.com/pdf%20folder/15.testo_thermography_guide.pdf	Practical Guide Solar Panel Thermography
6	https://www.wisein.org/wp-content/uploads/Best-Practices-Handbook-on-Performance-Evalution-Operations-and-Maintenance-of-Solar-PV-Power-Plants-in-India.pdf	Solar system best practices

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

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MSBTE Approval Dt. 04/09/2025 **Semester - 6, K Scheme**