ANNEXURE V

Course Structure and detailed syllabus for
Minor/ Honors in

- **VLSI Design & Technology**
  and
- **Solar Photovoltaics**

vetted in

8th Board of Studies

for

Department of

"Electronics and Communication Engineering"

ISLAMIC UNIVERSITY OF SCIENCE AND TECHNOLOGY

AWANTIPORA, J&K, INDIA-192122

Students interested in pursuing an Honors/Minor Degree have the option to enroll in the Specialization courses. Starting from the third semester onwards, students may enroll in one course per semester as an extra course for the award of Honors/Minor.

Honors is available to students in the ECE (parent department), while Minor is open to students in sister departments of SOET. Additionally, ECE students interested in pursuing a Minor have the opportunity to choose from available options in other sister department

Course Outline for Minor/Honors Degree in VLSI Design and Technology

Total Credits = 18

S.No	Semester	Course Code	Course Title		L	T	P	S	Hours Per Week	Credits	Mode
			Minor	Honors							
1	3rd	ECE 201S	Electronic Materials and Device Physics	Electronic Materials and Device Physics	3	0	0	1	3	3	Offline
2	4th	ECE 251S	Digital Logic Design using VHDL and Verilog	Digital Logic Design using VHDL and Verilog	2	0	2	-	4	3	Offline
3	5th	ECE 301S *ECE 303S	VLSI Design	*Advanced Digital Design	3	0	0	-	3	3	Offline
4	6th	ECE 302S/ ECE 351S	Organic Electronics/ VLSI Technology	Organic Electronics/ VLSI Technology	3	0	0	1	3	3	Offline
5	7th	ECE 401S	RF Design/ Relevant MOOCS Course	RF Design / Relevant MOOCS Course	3	0	0	0	3	3	Offline/ MOOCS
6	8th	ECE 451S	Analog CMOS Integrated Circuits	Analog CMOS Integrated Circuits	3	0	0	0	3	3	Offline

Note: Students pursuing Minor/Honors cannot opt for any of the above courses as elective in the regular B.Tech programme

Course Outline for Minor/Honors Degree in "Solar Photovoltaics"

Total Credits = 18

S.No	Semester	Course Code	Course Title		L	T	P	S	Hours Per Week	Credits	Mode
			Minor	Honors							
1	3rd	ECE 202S	Electronic Materials and Device Physics	Electronic Materials and Device Physics	3	0	0	1	3	3	Offline
2	4th	ECE 252S/ ECE 253S	Energy Sources/ Energy and its Resources	Energy Sources/ Energy and its Resources	3	0	0	1	3	3	Offline
3	5th	ECE 302S	Organic Electronics	Organic Electronics	3	0	0	1	3	3	Offline
4	6th	ECE 352S	Solar Photovoltaics: Fundamentals and Applications	Solar Photovoltaics: Fundamentals and Applications	2	0	2	0	4	3	Offline
5	7th	ECE 402S ECE 403S	Solar Cell Technology/ Energy and Environment	Solar Cell Technology/ Energy and Environment	3	0	0	1	3	3	Offline
6	8th	ECE 452S	PV System Design	PV System Design	2	0	2	0	4	3	Offline

Note: Students pursuing Minor/Honors cannot opt for any of the above courses as elective in the regular B.Tech programme

Course Code	Course Title	L-T-P-S
ECE 201S	ELECTRONIC MATERIALS AND DEVICES PHYSICS	

COURSE OBJECTIVE: To provide a fundamental understanding of the materials and devices used in the semiconductor industry.

COURSE OUTCOMES (COs):

CO1: Ability to understand the structure and physics of materials used in electronics

CO2: Ability to understand the different parameters and terminology used in describing electronic properties of materials

CO3: To acquire knowledge about the crystal lattices, and their defects.

CO4: Ability to understand different properties of materials that result in specific electrical, optical, and magnetic behavior

CO5: To acquire knowledge of the magnetic, electronic, dielectric, and optical properties of the materials.

CO6: To acquire knowledge regarding the quantum physics, energy bands, and carrier transport mechanism in semiconductors

Pre-requisite: None

UNIT-I: Classification of materials Materials used in electronic devices: Polymers, ceramics. Semiconductors and metals - their structure and properties, insulators, superconductors, dielectric, ferroelectric, and magnetic materials. **Crystal Structure of Solids:** Crystal directions and planes, crystal properties, defects: vacancies interstitial, Frenkel and Schottky defects; dislocations; grain boundaries, stacking faults; surfaces and interfaces.

UNIT-II: Elementary Quantum Physics, Semiconductors
Quantum mechanical approach to the structure of materials, energy bands in solids, electrical conductivity, doping, classification of semiconductors, extrinsic and intrinsic semiconductors, carrier concentration, and work function. Carrier transport mechanism: Scattering and drift of electrons and holes; diffusion and drift of carriers; Hall effect, temperature dependence, minority carriers and recombination, drift, diffusion, poisons equation, continuity equation.

UNIT-III: Magnetic Properties of Materials, Superconductors Dipole moment, permeability, classification of magnetic materials, saturation, and Curie temperature, superconductivity.

UNIT-IV: Dielectrics Materials Polarization, polarization mechanisms, piezoelectricity, dielectric constant, dielectric loss, dielectric breakdown in solids, capacitors and their construction, piezo-electricity, ohmic and non-ohmic contacts.

UNIT-V: Optical Properties Optical properties of materials, optoelectronic materials, optical absorption, absorption coefficient, light propagation in a homogeneous medium, absorption, scattering, luminescence, phosphors, LEDs, laser,

TEXT BOOK:

1. Principals of Electronic materials and devises, S.O. Kasap. Tata McGraw Hills, 4^{th} edition

Course Code	Course Title	L-T-P-S
ECE 202S	ELECTRONIC ENGINEERING MATERIALS	

COURSE OBJECTIVE: The objective of this course is to provide students a fundamental understanding of electrical, magnetic and optical properties of materials and to apply those fundamentals for selecting and developing materials for different engineering applications

COURSE OUTCOMES (COs):
CO1: To learn about different materials and the nature of bonding in materials,
CO2: To acquire knowledge about the lattices, and defects in crystalline materials.
CO3: To learn about dielectric materials.
CO4: To acquire knowledge of the mechanical, magnetic, thermal, electronic and optical properties of the materials.

Pre-requisite: None

UNIT-I: Classification of materials Metals, ceramics, polymers and composites, nature of bonding in materials: Metallic, ionic, covalent, and mixed bonding; structure of materials: fundamentals of crystallography, symmetry operations, crystal systems, bravais lattices, unit cells, primitive cells, miller indices, reciprocal lattice, common crystal structures, crystallographic planes and directions; structures of metals, Bragg's diffraction, crystal imperfections.

UNIT-II: Defects in crystalline materials 0-D, 1-D, and 2-D defects; vacancies, interstitials, solid solutions in metals and ceramics, Frenkel and Schottky defects; dislocations; grain boundaries, twins, stacking faults; surfaces and interfaces. Free electron theory: conduction in metals and alloys, conductors and resistors. Semiconductors: their properties and applications.

UNIT-III: Properties and Applications of Materials-I *Mechanical properties*: Mechanical properties of metals, ceramics, polymers and composite sat room temperature; stress-strain response (elastic, and plastic deformation).*Magnetic properties:* Origin of magnetism in materials, para-, dia-, ferro- and ferri- magnetism, black well, domain dimensions, anti-ferromagnetism, and ferromagnetism, ferrites, Magnetic Materials: Fe, Si, Ni, Co, Hard magnetic materials. *Thermal properties:* Specific heat, heat conduction, thermal diffusivity, thermal expansion, and thermoelectricity.

UNIT-IV: Properties and Applications of Materials-II *Electronic properties:* free electron theory, Fermi energy, density of states, elements of band theory, semiconductors, Hall effect, dielectric behavior, piezo-, and ferroelectric behavior. *Optical properties:* Refractive index, absorption, and transmission of electromagnetic radiation.

UNIT-V: Dielectric materials Electric & optical properties, polarization, piezoelectricity, polarizability and dielectric constant, dielectric loss, optical transition in solids, absorption, and emission of radiation. Materials for resistors, capacitors, and inductors, properties, and application of plastic materials. Superconductivity and superconductors.

TEXT BOOK:

1. Principals of Electronic materials and devises, S.O. Kasap. Tata McGraw Hills, 4th edition

Course Code	Course Title	L-T-P-S
ECE 251S	DIGITAL LOGIC DESIGN USING VHDL	

COURSE OBJECTIVE:VHDL can be used for Desigining hardware and for creating test entities to verify behaviour of hardware

COURSE OUTCOMES (COs)
CO1: To understand the basic knowledge of VHDL.
CO2: To identify VHDL modeling types.
CO3: To learn about combinational modules and sequential modules using VHDL.
CO4: To design a fundamental sequential circuit
CO5: To be able to design an elementary level system.

Pre-requisites: Digital Electronics and Logic Design.

UNIT-I: Introduction to VHDL and VHDL Modeling: Need of VHDL, HDL Design Flow, Code structure, Configurational Declaration, Package Declaration, Package body, Data Objects, Data Types, operators and attributes Behavioral modelling: variable and signal assignment Statements. Data flow modelling: concurrent and conditional signal assignment statement. Structural modelling:

UNIT-II: VHDL Combinational Circuits Modules component declaration and component instantiation.
VHDL code for Logic gates, Decoder, Encoder, Multiplexers, and De-multiplexers. Standard combinational modules: Implementation of Boolean algebra using VHDL.

UNIT-III: Introduction to Concurrent code and Sequential code: Concept of concurrent operators,
implementing sequential circuits with concurrent code. Design of ALU using concurrent code, Adder modules- Design of full-adder module and a Carry-look ahead Adder module. Implementation using operators.

UNIT-IV: Sequential Modules using VHDL VHDL code for SR, JK, D, T Flip Flop, Standard sequential
modules: Register Module, Shift register module, counter module.

UNIT-V: System level Modelling and Macro support. Introduction to Packages and Component, Block
level Modelling. Introduction to inbuilt-macro support, Introduction to Ipcores, Xpower analyser, synthesis report and its importance.

TEXTBOOKS:

1. Volnei A. pedroni, “Circuit Design and simulation with VHDL”, Second Edition,MIT Press,2017.

REFERENCE BOOKS:

1. J. Bhaskar, "A VHDL Primer", Addison Wesley, 1999.
2. Z. Navabi, "VHDL-Analysis and Modeling of Digital Systems", MGH

Course Code	Course Title	L-T-P-S
ECE 252S	ENERGY SOURCES	

COURSE OBJECTIVE: To develop in-depth knowledge for the following: Various renewable energy resources available at a location and assessments of its potential

COURSE OUTCOMES(COs):

CO1: Description and quantification of various energy resources – renewable and non-renewable

CO2: Knowledge of conventional energy sources

CO4: To Understand the availability and use of commercial energy sources

CO5: Energy from solar system – attainment and uses

CO6: To understand the possible future of hydrogen energy

Pre Requisite: None

UNIT-I: **Introduction** Definition of Power and energy, difference between power and energy, the role of energy in development, Limitation of renewable energy sources their usefulness seasonal nature, requirement, need for the use of new energy sources.

UNIT-II: Conventional energy sources Hydro Electric, Thermal, Nuclear, Non-Conventional Energy sources Bio-mass, geo-thermal, solar, wind energy, ocean energy, wave energy, advantages and disadvantages, challenges.

UNIT-III: Commercial energy sources fossil-fuels coal, oil, natural gas, hydroelectric power, nuclear, Non-commercial energy sources, wood, animal wastes, agricultural waste, cost of raw materials, transport problems, issues

UNIT-IV: Solar system: Energy from the sun, solar window, atmospheric effects, diffused radiations, Air mass, effect of Air Mass, seasonal effects, environmental effects on standard test conditions.

UNIT-V: Hydrogen energy Source and storage medium, generation of hydrogen, storage of hydrogen, conversion of hydrogen into useful energy, future of hydrogen, Future energy scenarios: summary of the class, students to summarize their experiences in the form of poster on any one topic, discussion on what are possible scenarios?

TEXT BOOKS:

1. Renewable energy; power for a sustainable future; oxford; Stephen peake; oxford university press- 2017

REFERENCE BOOKS:

1. Renewable energy systems; Devid M, Buchla, Thomas E kissell, Thomas, L Floyd; Pearson India Education Services Pvt. Ltd. 2017

2. Fundamentals of Renewable Energy Systems Paperback – D.Mukherjee, New Age International Publisher; First edition (2011) • Solar Power Hand Book, Dr. H. Naganagouda (2014).

Course Code	Course Title	L-T-P-S
ECE 301S	VLSI DESIGN	

COURSE OBJECTIVE: To provide understanding of the entire logic design process with the analysis from combinational and sequential digital circuit design.

COURSE OUTCOMES (COs):
CO1: Identify the various IC fabrication methods.
CO2: Express the layout of a simple MOS circuit using lambda-based design rules for subsystem design.
CO3: Differentiate various FPGA architectures and design an application using Verilog HDL
CO4: Concepts of modeling a digital system using Hardware Description Language.

Pre-requisite: Digital Electronics and Logic Design

UNIT-I: MOS Transistor Theory Review of MOS structure and operation, nMOS, pMOS enhancement transistor, IV characteristics, short channel effects, MOS capacitor, CV characteristics, scaling of MOS transistor, Introduction to CMOS circuits, quality metrics of digital design

UNIT-II: CMOS Inverter Operation of MOS transistor as a switch, CMOS logic, CMOS inverter (pull-up and pull-down), CMOS inverter static characteristics, noise margin, beta ratio, transistor sizing, switching characteristics of inverter (rise time, fall time, delay time), power consumption, static dissipation, dynamic dissipation

UNIT-III: CMOS Logic Design CMOS logic gate design (NAND and NOR logic), combinational logic, compound gate, ratioed logic, pseudo nMOS inverter, saturated load inverters, pass transistor logic, complementary pass transistor logic, transmission gate, dynamic logic, issues in dynamic design, glitching, cascading dynamic gates, domino logic, charge sharing, Bi-CMOS logic, layout

UNIT-IV: Sequential MOS Logic Circuits Multiplexer, MUX implementation in CMOS and transmission gates, CMOS subsystem design, design and implementation of adder, design methodology, carry ripple adder, carry-lookahead adder, carry skip adder, carry select adder, dynamic adder design, Manchester chain carry adder, transmission gate adder, SR flip-flop, memory elements–SRAM and DRAM cell, latches

UNIT-V: CMOS Process Flow Simplified CMOS process flow, CMOS technology, basic n-well and p-well process.

TEXT BOOKS:

1. Weste N.H.E. and Eshranghian K., Principles of CMOS VLSI Design, Wesley Publications.

REFERENCE BOOKS:

1. Rabaey J.M., Chandrakasan A. and Nikolic B., Digital Integrated Circuits: Analysis and Design, McGraw Hill Education

Course Code	Course Title	L-T-P-S
ECE 302S	ORGANIC ELECTRONICS	

COURSE OBJECTIVE: To gain the ability to tie molecular transport phenomena with macroscopic device. To analyze, troubleshoot, and design the next generation of organic electronic materials and devices.

COURSE OUTCOMES (COs):

CO1: To understand the physics and fundamental material properties of organic electronic materials.

CO2: To acquire a general background in the field of organic electronics and optoelectronics: basic theory, applications, challenges, and recent developments in the field of organic electronics.

CO3: To know and understand relevant fundamental scientific theory (qualitatively), and its relationship to organic semiconductor material and device design concepts.

CO4: To understand the applications of organic electronic materials in various electronic and optoelectronic devices.

Pre-requisite: Physics of Semiconductor Devices

UNIT I: Introduction to organic electronics, limitations of conventional electronics, advantages of organic electronics, review of quantum mechanics general comparison of inorganic versus organic devices

UNIT II: Electronic structure of organic molecules Atomic and molecular orbitals, LCAO, bonding and anti-bonding orbitals, orbital hybridization, HOMO and LUMO levels, conjugated molecules, organic semiconductor physics, energy levels in a molecule,

UNIT III

Photo physics of organic Molecules Electronic transitions, excitons, and energy transfer; charge generation and recombination mechanisms, polaron, optical processes, radiative lifetime, transport and injection, absorption/emission in a molecule.

UNIT IV: Electronic conduction in organic solids Conductivity (carrier concentration versus mobility), carrier generation, hopping transport, transport in organic semiconductors, mobility measurements, traps, multiple trap release model, grain-boundary potential barrier model, Gaussian disorder model

UNIT V: Organic Devices Organic LEDs, organic thin film transistors, organic solar cells, selected examples in current research

TEXT BOOKS:

1. "Organic Semiconductors" H. Meier, Verlag Chemie GmbH, 1974
2. "Physics of Organic Semiconductors" Wolfgang Brütting, John Wiley & Sons Canada

REFERENCE BOOKS:

1. "Organic Electronics: Materials, Manufacturing, and Applications", Hagen Klauk, John Wiley & Sons.
2. "Organic Electronics: Materials, Processing, Devices and Applications", Franky So, CRC Press,

E-RESOURCES

https://youtube.com/playlist?list=PLtCXw_RzWB3gjVjK5FAxLJUIEFng8VPOj&si=D2jI4uhOhUQKFl9H

Course Code	Course Title	L-T-P-S
ECE 303S	DIGITAL SYSTEM DESIGN	

COURSE OBJECTIVES: This course focuses on design digital system from scratch. The course focuses on designing combinational and sequential building blocks, using these building-blocks to design bigger digital systems. During this course we also learn how to use Verilog to design/model a digital system.

COURSE OUTCOMES (COs):
CO1:Explain the functionality of a digital subsystem.
CO2:Translate Boolean expressions using Hardware Description Language.
CO3: Partition digital subsystems and apply improvement techniques .
CO4: Exploit the critical path of a network

Pre Requisite: Digital Electronics, Verilog, VHDL

UNIT I: multiple clock domains, Synchronous and asynchronous design styles. Interface between synchronous and asynchronous blocks.

UNIT II: Meta-stability and techniques for handling it. Interfacing linear and digital systems, data conversion circuits.

UNIT III: Design of finite state machines, state assignment strategies. Design and optimization of pipelined stages.

UNIT IV: Use of data flow graphs, Critical path analysis,

UNIT V: pipelining and scheduling strategies for performance enhancement. Implementation of DSP algorithms.

TEXT BOOKS:

1. Circuit Design and Simulation with VHDL by Volni A. Pedroni", MIT press, 2011

REFERENCE BOOKS:

1. J.Bhaskar, "A VHDL Synthesis Primer", BSP, 2003.

ONLINE RESOURCES:

Verilog: https://onlinecourses.nptel.ac.in/noc24_cs61/preview
Analog IC Design: https://onlinecourses.nptel.ac.in/noc22_ee37/preview
VLSI PHYSICAL DESIGN: https://onlinecourses.nptel.ac.in/noc21_cs12/preview

Course Code	Course Title	L-T-P-S
ECE 351S	VLSI TECHNOLOGY	

COURSE OBJECTIVE: To provide understanding of the entire logic design process with the analysis from combinational and sequential digital circuit design

COURSE OUTCOMES (COs):
CO1: To understand the fabrication process of IC Technology.
CO2: To learn the MOS process technology.
CO3: Analysis of the physical design process of VLSI
CO4: To be aware of the trends in Semiconductor technology & its impact on Scaling & Performance.

Pre-requisite: VLSI Design

UNIT I: Crystal growth & wafer preparation, Processing considerations: Chemical cleaning, getting the thermal Stress factors, etc. Epitaxy-Vapour Phase Epitaxy, Basic Transport processes & reaction kinetics, doping & auto doping, equipments, & safety considerations, buried layers, epitaxial defects, molecular beam epitaxy, equipment used, film characteristics, SOI structure.

UNIT II: Oxidation-Growth mechanism & kinetics, Silicon oxidation model, interface considerations, orientation dependence of oxidation rates thin oxides. Oxidation technique & systems dry & wet oxidation, Masking properties of SiO2. Diffusion -Diffusion from a chemical source in vapor form at high temperature, diffusion from a doped oxide source, diffusion from an ion implanted layer.

UNIT III: Lithography -Optical Lithography: optical resists, contact & proximity printing, projection printing, electron lithography: resists, mask generation. Electron optics: roster scans & vector scans, variable beam shape. X-ray lithography: resists & printing, X- ray sources & masks. Ion lithography.

UNIT IV: Etching - Reactive plasma etching, AC & DC plasma excitation, plasma properties, chemistry & surface interactions, feature size control & apostrophic etching, ion enhanced & induced etching, properties of etch processing. Reactive Ion Beam etching, Specific etches processes: poly/ polycide, Trench etching.

UNIT V: Metallization - I, Problems in Aluminium Metal contacts, IC BJT - From junction isolation to LOCOS, Problems in LOCOS + Trench isolation, More about BJT Fabrication and Realization, MOSFET - Metal gate vs. Self-aligned Poly-gate, CMOS Technology

TEXT BOOKS:

1. S. M. Sze, "Modern Semiconductor Device Physics", John Wiley & Sons, 2000.

REFERENCE BOOKS:

1. B.G. Streetman, "Solid State Electronics Devices", Prentice Hall, 2002.
2. Chen, "VLSI Technology" Wiley, March 2003.
3. S. K. Gandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, Second Edition, Wiley.

Course Code	Course Title	L-T-P-S
ECE 352S	SOLAR PHOTOVOLTAICS: FUNDAMENTALS AND APPLICATIONS	

COURSE OBJECTIVE: To develop a comprehensive technological understanding in solar PV system components. To provide in-depth understanding of design parameters to help design and simulate the performance of a solar PV power plant.

COURSE OUTCOMES (COs):

CO1: To understand the basics of solar cells.

CO2: To learn about the performance evaluation parameters of the solar cells and the influence of different parameters on the efficiency of solar cells.

CO3: To learn about the different parameters that are important for the design of solar cells.

CO4: To learn about thin film solar cells and other emerging solar cell technologies.

Pre-requisite: Physics of Semiconductor Devices, Electronic Engineering Materials

UNIT-I: Introduction to Solar Cells pn-junction under illumination, generation of photovoltage, light generated current, IV equation of solar cells, solar cell characteristics, solar cell parameters, losses in solar cells, model of a solar cell, effect of series and shunt resistance on efficiency, effect of solar radiation on efficiency, effect of temperature on efficiency.

UNIT-II: Design of Solar Cells Solar cell design, design for high I_{sc}, requirements for high short circuit current, choice of junction depth and its orientation, minimization of optical losses, minimization of recombination, design for high V_{oc}, requirements for high open circuit voltage, design for high fill factor, base resistance, emitter resistance.

UNIT-III: Thin Film Solar Cell Generations of solar cells, generic advantages of thin film technologies, materials for thin film technologies, use of transparent conductive oxide and light trapping, possible solar cell structures, substrate, and superstrate configuration.

UNIT-IV: Photovoltaic Solar Energy Materials Amorphous silicon solar cells: key aspect of material, solar cells structure, cadmium telluride solar cells, chalcopyrite (CIGS) solar cells,

UNIT-V: Emerging solar cell technologies and concepts Organic solar cells: material properties, solar cell structure, commonly used materials, dye-sensitized solar cells, GaAs solar cells, thermos-photovoltaics, beyond single junction efficiency limit, approaches to overcome single junction efficiency limit.

TEXT BOOKS:

1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI

Course Code	Course Title	L-T-P-S
ECE 401S	**RF INTEGRATED CIRCUITS**	

COURSE OBJECTIVES: This course focuses on with the analysis and design of RF integrated circuits and systems. Providing a systematic treatment of RF electronics. The course discusses the necessary background knowledge from microwave and communication theory and leads the reader to the design of RF transceivers and circuits. The course emphasizes both architecture and circuit level issues with respect to monolithic implementation in VLSI technologies.

COURSE OUTCOMES (COs):
CO1: Explain basic concepts of RF systems
CO 2: Explain the functionality of a communication system
CO 3: Explain various transceivers.
CO 4: Explain structures and shapes passive devices in Integrated circuits.

Pre-requisites: Analog and Digital Communication

UNIT I: Basic Concepts of RF design: Non-linearity, Noise and Impedance transformation, passive impedance transformation.

UNIT II: Communication concepts: Revision to Analog and Digital Communication. Introduction
to Mobile RF Communications, Medium Access Techniques, Wireless Standards GSM etc,

UNIT III: Transceiver architectures: General consideration, Receiver Architectures, Transmitter
architectures, OOK transceivers.

UNIT IV: LNA and Mixers: introduction to Low noise amplifiers, LNA topologies, concept of Gain and Band Switching. General considerations for mixers, topologies of mixers

UNIT V: Introduction to Passive devices: Inductor and its shapes, Transformer structures, T-Line structures, Constant capacitors.

TEXT BOOKS:

1. RF Microelectronics By Behzad Razavi, PHC second edition 2011Synthesis Primer", BSP, 2003.

Course Code	Course Title	L-T-P-S
ECE 402S	SOLAR CELL TECHNOLOGIES	

COURSE OBJECTIVE: Recognize/use basic solar technology. Develop a comprehensive technological understanding in solar PV system components.

COURSE OUTCOMES (COs):

CO1: To learn about the necessary steps required for the production of Si wafers
CO2: To acquire the knowledge of process flow of commercial Si cell technology
CO3: To become aware of the role of surface engineering of materials to modify/improve the surface properties
CO4: To be able to select the suitable thin film deposition technique/surface modification method to achieve the required surface property

Pre-requisite: Solar Photovoltaics, Fundamentals and Applications

UNIT-I: Production of Silicon Growth of solar PV industry and Si requirement, crystalline cells: mono-crystalline and poly- crystalline cells, steps in producing Si wafers, production of metallurgical grade Si (MGS) and electronics grade Si (EGS), production of Si-wafers, Si-sheets, Si-feedstock for solar cell industry, solar grade silicon, Si usage in solar PV.

UNIT-II: Silicon Wafer-Based Solar Cell Technology Development of commercial Si solar cells, process flow of commercial Si cell technology, processes used in solar cell technologies, high-efficiency Si solar cells: passivated emitter solar cells, buried contact solar cells, rear point contact solar cells, passivated emitter, and rear contact. sawing and surface texturing, diffusion process, thin film layers, Metal contact

UNIT-III: Thin Film Solar Cell Technologies Advantage of thin film, thin-film deposition techniques: evaporation, puttering, LPCVD, APCVD, plasma enhanced CVD, hot wire CVD, closed space sublimation (CSS), ion-assisted deposition (IAD), spin coating, atomic layer chemical vapour deposition, molecular beam epitaxy, lithography,

UNIT-IV: Inter-diffusion, Reactions and Transformations in Thin Films Fundamentals of diffusion, Inter-diffusion in thin metal films, Mass transport in thin films; Properties and characterization of thin films-optical, electrical, mechanical and magnetic, structural morphology of deposited films and coatings

UNIT-V: Surface Engineering of Nanomaterials Hybridization of nanomaterials, microencapsulation, synthesis, processing and characterization nano structured coatings and their application

TEXT BOOKS:

1. Modern Surface Technology, Edited by Friedrich-Wilhelm Bach, Andreas Laarmann, and Thomas Wenz, WILEY-VCH Verlag GmbH & Co.

2. M. H. Francombe, S. M. Rossnagel, A. Ulman, Frontiers of Thin Film Technology, Vol. 28, Academic press, 2001.

REFERENCE BOOKS:

1. K. L. Chopra, Thin Film Phenomena, McGraw Hill, 1979.R.F. Bunshah, Deposition Technologies for Films and Coatings, Noyes Publications, New Jersey, 1982.
2. M. Ohring, Materials Science of Thin Films, 2nd ed., Academic Press, San Diego, 2002.
3. Nanomaterials and Surface Engineering, Edited by Jamal Takadoum, John Wiley & Sons, Inc., USA

Course Code	Course Title	L-T-P-S
ECE 403S	ENERGY AND ENVIRONMENT	

COURSE OBJECTIVE: To focus on the intersection of energy production, consumption, and environmental impact. Energy and Environment courses cover a range of topics related to sustainable energy, environmental conservation, and the challenges posed by energy use.

COURSE OUTCOMES (COs):
CO1: To learn about environmental concerns of energy extractions
CO2: To acquire knowledge about waste management and pollution control
CO3: To acquire knowledge about the pollution caused by the power plants
CO4: To acquire knowledge about the global environmental concern and environmental protection
CO5: To become aware of the energy conservation

Pre-requisite: None

UNIT I: Environment concerns of energy extractions Environment effects of energy extractions, conversion and use. Primary and secondary pollution, air, thermal and water pollution, depletion of ozone layer, global warming, Methods of environmental impact assessment, Sustainability issues of energy use- Future energy system, Clean energy technologies.

UNIT II: Waste management and pollution control Waste as a source of energy - Industrial, domestic and solid waste as a source of energy. Pollution control - Causes process and exhaust gases and its control, mechanism and devices for pollution control.

UNIT III: Pollution from power plants and its control Pollution - Pollution due to thermal power station and its control and systems. Pollution due to nuclear power generation, radioactive waste and its disposal, effect of hydroelectric power stations on ecology and environment.

UNIT IV: Environmental protection and carbon credits Global environmental concern - United Nations framework convention on climate change (UNFCC), protocol, clean development mechanism (CDM), benefits to developing countries, building a CDM project, Environmental impacts -Environmental degradation due to energy production and utilization

TEXT BOOKS:

1. The Climate Solution; Mridula Ramesh; Neelkamal publication - 2009

REFERENCE BOOKS:

1. " Green Power: Eco-Friendly Energy Engineering", Khartchenko . N.V, Tech Books, and New Delhi, 2008.
2. Handbook of energy and environment in India; Banerjee BP , Oxford University

press 2005 India
3. “Environmental Science”, Cunningham .W.P,11th ed., McGraw-Hill, 2010.

Course Code	Course Title	L-T-P-S
ECE 451S	ANALOG CMOS INTEGRATED CIRCUITS	

COURSE OBJECTIVE: This course builds the basic concepts and the design of advanced CMOS Analog Integrated Circuits. This course focuses on the concepts of MOSFETs and the design of amplifiers and gives practical aspects of CMOS analog IC design.

COURSE OUTCOMES (COs):
CO1: Differentiate Analog, Digital, and Mixed Signal CMOS Integrated Circuits
CO2: Design current sources and voltage references for given specifications.
CO3: Design single-stage MOS Amplifiers
CO4: Design current mirrors
CO5: Study the influence of noise on CMOS circuits

Pre-requisite: VLSI Design

UNIT-I: Introduction to Analog IC Design Concepts of Analog Design, General consideration of MOS devices, MOS I/V Characteristics, Second order effects, MOS device models. MOS Capacitance.

UNIT-II: Amplifiers Single-stage amplifiers: Common source stage, Common gate stage, source follower configuration, Cascode & folded cascode, Differential amplifiers: Single-ended and differential operation, Basic Differential pair- Common mode response, Differential pair with MOS loads- Gilbert Cell.

UNIT-III: Current Mirrors Basic current mirrors, Cascode current mirrors, Active current mirrors, Large and Small signal analysis, Common mode properties.

UNIT-IV: Frequency Response of Amplifiers General considerations- Miller Effect and Association of Poles with Nodes, Common source stage, Source followers, Common gate stage, Cascode stage, Differential pair.

UNIT V: Noise Statistical characteristics of noise- Types of noise, Representation of noise in circuits, Noise in single-stage amplifiers, Noise in differential pairs, Noise Bandwidth.

TEXT BOOKS:

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill.
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", Wiley.

REFERENCE BOOKS:

1. Phillip Allen and Douglas Holmberg "CMOS Analog Circuit Design", Oxford University Press.

2. Grebene, "Bipolar and MOS Analog Integrated circuit design", John Wiley & sons,
3. Yannis Tsividis, "Operation and Modeling of the MOS Transistor" by Oxford University Press
4. A.S. Sedra and K.C. Smith, "Microelectronic Circuits-Theory & Applications" Oxford, 2013.

Course Code	**Course Title**	**L-T-P-S**
ECE 452S	**PHOTOVOLTAIC SYSTEM DESIGN**	

COURSE OBJECTIVES: To develop a comprehensive technological understanding in solar PV system components. To provide in-depth understanding of design parameters to help design and simulate the performance of a solar PV power plant. To pertain knowledge about planning, project implementation

COURSE OUTCOMES (COs)
CO1: To know about photovoltaic systems
CO2: To know MTP& Buck Boost & Flyback converters
CO3: To have knowledge of Photovoltaic modules – series & parallel
CO4: Be familiar with stand-alone and grid PV systems

Pre Requisite: Physics of Semiconductor Devices, Electronic Engineering Materials

UNIT I: Introduction to photovoltaic systems, advantages, review of semiconductor Physics-Energy bands, charge carriers, charge carrier transport, photovoltaic cell characteristics and equivalent circuit, the effect of temperature and irradiance, open circuit and short circuit and peak power parameter.

UNIT II: Cell efficiency, STC, fill factor of photovoltaic modules, Maximum power point tracking (MPPT) Techniques- open circuit voltage, short circuit current, perturb and observe, incremental conductance. Input impedance of Buck, Boost and Buck-Boost converters. Flyback converters.

UNIT III: Photovoltaic modules, series, and parallel connection, Mismatch in series and parallel connection, Hot spots and use of bypass diodes in modules, design and structure, wattage of modules, I-V equation, and output power.

UNIT IV: Stand-alone and grid-tied PV systems, Batteries-Capacity, C-rate, Energy and power density, classification, losses, parameters, PV inverters, charge controllers, PV wire sizing.

UNIT V: Atmospheric effects, Air mass, energy with atmospheric effects, Solar radiation, sun-earth movement, angle of sunrays on solar collector, sun tracking-single axis and dual axis.

TEXT BOOKS:

1. Chetan Singh Solanki, "Solar Photovoltaics – Fundamentals", 3rd Edition, PHI.

REFERENCES:

1. Weidong Xiao, "Photovoltaic Power System", John Wiley.