

BHARATHIAR UNIVERSITY, COIMBATORE-641046

ELECTRONICS AND INSTRUMENTATION

M.Phil./Ph.D.(FT/PT)- PART I - SYLLABUS
(with effect from 2008-09 onwards)

PAPER I : Research Methodology

PAPER II : Research Trends in Electronics and Instrumentation

PAPER III : Special Papers :

1. Computer Based Instrumentation
2. Bio Medical Instrumentation
3. Embedded Systems
4. VLSI System Design
5. MEMS and their application
6. Digital Signal Processing
7. RTOS and Vx Works
8. Molecular Physics
9. Thin Film Technology

BHARATHIAR UNIVERSITY : COIMBATORE-641046
M. Phil./ Ph.D. (FT / PT) – Eletronics & Instrumentation
M.Phil – Part-I Syllabus (with effect from 2008-09 onwards)

PAPER-I : RESEARCH METHODOLOGY

UNIT I : HIGHER EDUCATION AND LEARNING

Historical Perspectives – Objectives and Role of Higher Education – Learning and Learning Hierarchy – Information Processing – Learning Events and Outcomes – Motivation.

UNIT II : TEACHING TECHNOLOGY : DESIGNS

Teaching Technology: Meaning, concept and scope – Instructional Designs: Objective based, Skill based, Competency based, Learning style based and Model based.

UNIT III: METHODS AND TECHNIQUES OF TEACHING

Large group Techniques: Lecture, Modified Lecture, Seminar, Symposium, Panel Discussion, Team teaching, Project Approach and Workshop - Small Group Techniques: Group Discussion, Simulation, Role Playing, Buzz Technique, Brain Storming, Case discussion and Assignment—Systems Approach in Education.

UNIT IV: Z-TRANSFORM

The Z-transform-Properties-Rational Z Transform-Incursion of the Z Transform-The one sided Z-Transform.

Linear Time Invariant Systems: Introduction-Differential Equation and its Relationship with System Functions-Impulse Response and Frequency Response.

UNIT V: DISCRETE FOURIER TRANSFORM

Frequency Domain Sampling-Properties of DFT-Linear Filter Method Based of the DFT-Fast Fourier Transform Algorithm (FFT): Efficient Computation of DFT-Structure and Design of FIR System-Structure and Design of IIR Systems Realization of Digital Linear System.

TEXT BOOKS

For Units I to III

Vedanayagam, E.G.(1989) Teaching Technology for College Teachers, New Delhi: Sterling Publishers (P) Ltd

For Unit IV & Unit V:

1. J.G.Proakis and D.G.Manollakis,"Digital Signal Processing Principles. Algorithms and Applications" Pearson education, New Delhi 2003/PHI.
2. S.K.Mitra, Digital Signal Processing – A Computer Based Approach Tata Mc Graw Hill, New Delhi, 2001.

PAPER-II : Research Trends in Electronics and Instrumentation

UNIT I: TRANSDUCERS

Introduction to Transducers – Selecting Transducers – Classification of Transducers – Analog and Digital Transducers – Characteristic Features – Electrical Transducers: Resistive Transducers, Capacitive Transducers, Inductive Transducers –Thermo Couple – Piezo Electric Transducers – Optical Encoders.

UNIT II: DETECTORS

Types of Detectors – Primary and Secondary Detectors – Mechanical Detectors:Mechanical Spring – Pressure Sensitive Detectors – Temperature Detectors – Thermister Hydro Pneumatic Detectors – Opto Electronic Sensors: Photo Voltaic Cell, Photo Conductive Cell, Photo Transistor, Semiconductor Photo Diode – Characteristics and Its Application – Rotary Variable Differentiable Transformer (RVDT) - Linear Variable Differentiable Transformer (LVDT) – Hall Effect Principles and Its Operation

UNIT III: DIGITAL SYSTEM

Signal Conditioning and Data Conversion – Introductory – Sample and Hold Circuits – Analog Multiplexer and Demultiplexer – D/A Converter – Types – A/D Converter - Successive A/D Conversion – Flash A/D Converter – Counter Type A/D Converter – Dual Slope A/D Converter – Integrator and Differentiator Circuits – Electronic – Analog Computation.

UNIT IV: MICROCONTROLLERS AND EMBEDDED SYSTEMS

Introduction to 8051 Microcontroller – Flip Flops – Memories in Intel 8051 Based Microcontrollers - 8051 Microcontroller Architecture: CPU, Addressing Mode, External Addressing , Interrupts – 8051 Instruction set.

Embedded System Software Architecture : Round Robin – Round Robin with Interrupts – Function Queue Scheduling Architecture –Real Time Operating Systems Architecture – Selecting an Architecture – Tasks And Task States –Task And Data – Semaphores And Shared Data

UNIT V: INTERFACE AND STANDARDS

Serial Communication Standards – Error Detection – Introduction To Protocols- Open System Interconnection Model – Industrial Protocols – HART Protocols – Open Industrial Field Bus And Device Net System – Local Area Networks.

REFERENCE BOOKS:

1. D.V.S. Murthy, “Transducers And Instrumentation,“Prentice-Hall of India,2nd Edition, 2008
2. C.S.Rangan, G.R.Sarma,V.S.V.Mani,“Instrumentation Devices & Systems”, Tata McGraw Hill, 2nd Edition,1983
3. John Park, Steve Mackey, Edwin Wright,“ Practical Data Communications for Instrumentation and control” Elsevier Newnes,2003

PAPER III: 1. COMPUTER BASED INSTRUMENTION

UNIT I: 8051 CORE MICROCONTROLLER

8051 Core Microcontroller: Introduction-Memory Organization Logical Separation of Program memory and Data memory-Program Memory-Data Memory-Instruction Set-CPU Timing-Interrupt structure.

UNIT II: PIC MICROCONTROLLER

PIC 16F877 Microcontroller: Introduction –Architecture-Pin Out Diagram –Memory Organization-ALU-Status Register-Option Register –INTCON Register-Program Counter – Watch Dog Timer –Sleep Ports Interrupt-Timer-Instruction set.

UNIT III:PC HARDWARE

Special Features Of 286, 386, 486,Pentium Series Processor-Motherboard types and Classification-Memory Mapping –I/O address-RAM Types-I/O Cards-Basic Concepts Of FDD and HDD-I/O Slot-Com port-LPT Port-Interrupt-BIOS-TSR Programs.

UNIT IV: INTERFACING CONCEPT

Input Output Interfacing-Practical Interface Considerations-Logical level –Serial drive –Capacities –Driving heavy Loads –Driving AC Loads-Serial Format-Asynchronous/Synchronous Serial Data Communication-MODEM –Parallel/Serial Interface.Interfacing Keyboard –Interfacing Alphanumeric Display-Interfacing ADC-interfacing DAC-Interfacing LCD Module-Interfacing Stepper Motor-Temperature Monitoring –design of 8255 card for PC-Optical Motor Shaft Encoder.

UNIT V: COMPUTER –BASED CONTROLLER

Introduction- Computer-Based Controller-Hardware Configuration, Software Requirements-Other Computer applications –Data Logging, Supervisory Control –Control system Networks-Development, General Characteristics, field Bus Types.

REFERENCE BOOKS :

- UNIT I:
1. Intel Manual Embedded Microcontroller
 2. Ayala K.J.-The 8051 Microcontroller Architecture Programming and Applications -3rd Edition-Penram International.
 3. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D.McKinlay, The 8085 Microcontroller and Embedded systems, using Assembly and C,2nd Edition Prentice Hall, 2008
- UNIT II:
1. PIC 16F877 DATA Sheet
 2. PIC Micro Mid Range MCU Family Reference Manual.
- UNIT III:
1. Stephan J.Bigelow-Trouble Shooting, Maintaining & Repairing PC's-Tata McGraw Hill, 2nd Edition.
 2. B.Govindarajalu-IBM PC and Clones Hardware Troubleshooting and Maintenance- Tata McGraw Hill.
 3. Peter Norton –Inside IBM PC and PS/2-4the edition, Prentice Hall of India.

UNIT IV: 1. Ronald J.Tocci, Leots P.Laskowski-Microprocessor and microcomputer Hardware and Software-Prentic Hall of India.

UNIT V: 1. Douhgles V.Hall-Microprocessor and Interfacing Programming and Hardware-Tata McGraw Hill.

2. Ramesh S.Goankar--Microprocessor and Interfacing Programming and Application with 8085/8080A –3rd-Edition- Wiley Eastern Limited.

2. BIO-MEDICAL INSTRUMENTATION

UNIT I: PHSYIOLOGY AND TRANSDUCERS

Cell and its structure-Action and resting-Potential propagation of action potential-Sodium pump-Nervous system-CNS-PNS –Nerve cell-Synapse-Cardio pulmonary system-Physiology of heart and lungs Circulation and respiration-Transducers-Different types-Piezo-electric, ultrasonic, resistive, capacitive, inductive transducers-Selection criteria

UNIT II:ELECTRO-PHYSIOLOGICAL MEASUREMENTS

Basic components of biomedical system-Electrodes-Micro, needle and surface electrodes-amplifiers-Preamplifiers, differential amplifiers, chopper amplifiers-isolation amplifier.ECG-EEG-EMG-ERG-Lead systems and recording methods-Typical waveforms.

UNIT III:NON-ELECTRICAL PARAMETER MEASUREMENTS

Measurement of blood pressure-Cardiac output-Cardiac rate-Heart sound-Respiratory rate-Gas volume-Flow rate of CO₂,O₂ in exhaust air-pH of blood, ESR, GSR measurements-Plethysmography

UNIT IV:MEDICAL INSTRUMENTATION

X-ray machine-Radio graphic and fluoroscopic techniques-Computer tomography-MRI –Ultrasonography-Endoscopy-Thermography-Different types of biotelemetry systems and patient monitoring-Electrical safety.

UNIT V:ASSISTING AND THERAPEUTIC EQUIPMENTS

Pace makers-Defibrillators-Ventilators-Nerve and muscle stimulators-Diathermy-Heart-Lung machine-Audio meters-Dializers.

TEXT BOOKS

1. Lesilie Cromwell, Fred J.Weibell,Erich A.Pfeiffer,"Bio-Medical Instrumentation and Measurements" II edition, Pearson Education,2002/PHI
2. R.S.Khandpur,"Handbook of Bio-Medical Instrumentation"Tata Mc Graw Hill Publishing Co.Ltd.2003.

REFERENCE BOOKS

1. M.Arumugam,Bio-Medical Instrumentation,"Anuradha Agencies,2—3.
2. L.A.Geddes and L.E.Baker,"Principles of Applied Bio-Medical Instrumentation" John Wiley & Sons 1975.

3. EMBEDDED SYSTEMS

UNIT I: INTRODUCTION TO EMBEDDED SYSTEMS

Introduction – Features – microprocessors – ALU - Von Neumann and Harvard Architecture – CISC and RISC - Instruction pipelining ,Microcontroller: characteristics and Features, Controller overview and architecture – PIC 16F 84 – Philips80C552 – Motorola 68HC05/08, Examples of Embedded Systems: Telegraph and Bar coded scanner

UNIT II: PIC MICROCONTROLLERS

PIC Microcontrollers: CPU Architecture and Instruction Set –External Interrupts—Timers I/O port Expansion—analog to Digital Converter –UART -I²C Bus for Peripheral Chip Accessories—Special Features.

UNIT III: MC68HCXX—MOTOROLA MICROCONTROLLERS

MC68HC05: Architecture – Registers—Addressing Modes –MC68HC08:Introduction Memory Map Registers—Addressing modes-- MCHC11:INTRODUCTION—Expanded Modes—Registers - Addressing modes—Erasing and Programming-MC68HC11: EEPROM, MC68HC12: Architecture-- Expanded Modes Registers - Addressing modes.

UNIT IV: SOFTWARE ARCHITECTURE AND RTOS

Soft ware Architecture: Round Robin--: Round Robin with interrupts—Function Queue. Scheduling Architecture RTOS: Architecture—Tasks and Task States—Tasks and Data—Semaphores and Shared Data—Message Queues—Mail Boxes and pipes—Timer Functions—Events—Memory Management Interrupt Routines.

UNIT V: SOFTWARE DEVELOPMENT TOOLS AND DEBUGGING TECHNIQUES

Development Tool: Cross Compiler—Cross Compiler –Cross Assemblers –Linker / locator PROM Programmers – ROM Emulator –In Circuit Emulators—Debugging Techniques: Software Techniques on Development –Host—Simulators—The Assert Macro – Laboratory Tools.

TEXT BOOKS/REFERENCES:

1. Rajkamal – Embedded Systems Architecture, Programming and Design, TMH, 2008
2. Tim wilmshurst—An Introduction to Design of Small Scale Embedded systems—Palgrave Publications.
3. John B.Peatman Design with P/C Microcontrollers—Pearson Education.
4. Johnathan. w.valvano –Embedded Microcomputer Systems, real time interfacing- Brooks/ Cole, 2000.
5. David E.Simon –An Embedded Software Primer Pearson Education, 1999.

4. VLSI SYSTEM DESIGN

UNIT I

VLSI technology- NMOS, CMOS and BICMOS circuit fabrication. Layout design rules. Stick diagram. Latch up.

UNIT II

System design using HDL- circuit and system representation. Hierarchical representation of digital system. An overview of Verilog. Basics of verilog, operators, hierarchy, procedures and assignments. Timing controls, delay, tasks and functions. Control statements. Test benches.

UNIT III

VLSI logic circuits and analysis- MOS and CMOS switches. Implementation of logic circuits using MOS and CMOS technology, multiplexers and memory, MOS transistors, threshold voltage, MOS device design equations. MOS models, small-signal AC analysis. CMOS inverters, propagation delay of inverters, power dissipation.

UNIT IV

Programmable logic devices- antifuse, EPROM and SRAM techniques. Programmable logic cells. Programmable inversion and expander logic. Design flow for VLSI circuits. Computation of interconnect delay.

UNIT V

VLSI testing -need for testing , manufacturing test principles, design strategies for test, chip level and system level test techniques.

REFERENCE BOOKS :

N.H.E.Weste etal, CMOS VLSI design, (3/e), Pearson , 2005

J. Smith, Application Specific Integrated Circuits, Addison Wesley, 1997.

Uyemura, Introduction to VLSI Circuits and Systems, Wiley, 2002.

5. MEMS AND THEIR APPLICATION

UNIT I: OVERVIEW OF MEMS & MICRO SYSTEM

MEMS & Micro systems - typical MEMS & Micro system products – Evaluation of Micro fabrication – Microsystems and Microelectronics –The Multidisciplinary nature of Micro Systems design and Manufacture –Micro Systems and miniaturization – applications of Micro Systems in Automotive industry – applications of Microsystems in other industries.

UNIT II: WORKING PRINCIPLES OF MICROSYSTEMS

Micro sensors – Micro actuation using Thermal Forces – Actuation Using shape memory Alloys – Actuation Using Piezoelectric crystals – Actuation using Electrostatic forces – MEMS with Micro Actuators – Micro Accelerometers – Micro Fluidics.

UNIT III: MATERIALS FOR MEMS AND MICROSYSTEMS

Introduction- Substrates and Wafers- Active Substrate Materials – silicon as a substrate Material – Silicon Compounds- Silicon Piezoresistors – Gallium Arsenide – Quartz – Piezoelectric Crystals- Polymers- Packaging Materials.

UNIT IV: MICROSYSTEMS FABRICATION PROCESSES

Introduction- Photolithography – Ion Implantation – Diffusion – Oxidation – chemical Vapour Deposition – Physical Vapour Deposition – Sputtering- Deposition by Epitaxy – Etching – Summary of Micro fabrication.

OVERVIEW OF MICROMANUFACTURING:

Introduction – Bulk manufacturing – Surface Manufacturing- The LIGA Process Summary of Micro manufacturing.

UNIT V : MICROSYSTEMS DESIGN

Introduction – Design considerations – Process Design – Photolithography – Thin Film Fabrications – Geometry Shaping – Mechanical Design – Mechanical design using Finite Element Method Design of a Silicon Die for Micro pressure sensor – Design of Micro fluidic Network systems – Design case – Computer Aided Design.

MICROSYSTEM PACKAGING

Micro Systems Packaging (Types) – Essential Packaging Technologies (Types)

REFERENCE BOOKS :

Tai Ran Hus – MEMS & Micro systems Design and Manufacture – Tata McGraw Hill.

6. DIGITAL SIGNAL PROCESSING

UNIT I: INTRODUCTION

Classification of systems: Continuous, discrete, linear, casual stable, dynamic, recursive, time variance, classification of signals: continuous and discrete, energy and power, mathematical representation of signals: spectral density, sampling technique, quantization, quantization error, Nyquist rate, aliasing effect

UNIT II: DISCRETE FOURIER TRANSFORM & COMPUTATION

DFT properties, magnitude and phase representation – computation of DFT using FFT algorithm – DIT & DIF – FFT using radix 2 – Butterfly structure

UNIT III: FFT

Introduction of DFT – Efficient Computation of DFT – Properties of DFT – FFT algorithms – Radix – FFT algorithm – Decimation in Time – Decimation in Frequency algorithms – Use of FFT- algorithms in Linear Filtering and correlation.

UNIT IV: DIGITAL FILTERS DESIGN

amplitude and phase response of fir filters – linear phase filters – windowing techniques for design of linear phase FIR filters – rectangular, Hanning, Kaiser windows – Frequency sampling techniques – IIR Filters – magnitude response – Phase response – group delay – Design of Low Pass Butterworth filters (low pass)- Bilinear transform – Prewarping. impulse invariant transformation

UNIT V: DIGITAL SIGNAL PROCESSORS

Introduction to DSP architecture – Harvard architecture- Dedicated MAC unit – Multiple ALUS, Advanced addressing modes, pipelining, Overview of instruction set of TMS320CSX and C54X

TEXT BOOKS

1. J.G.Proakis and D.G.Manolakis, "Digital Signal Processing Principles. Algorithms and Applications" Pearson education, New Delhi 2003/PHI.
2. S.K.Mitra, Digital Signal Processing – A Computer Based Approach Tata Mc Graw Hill, New Delhi, 2001.

REFERENCE BOOKS

1. Alan V.Oppenheim, Ronald W.Schafer and John R.Buck, "Discrete-Time Signal Processing" Pearson Education, New Delhi, 2003.
2. B.Venkataramani, M.Baskar, "Digital Signal Processors, Architecture, Programming and Applications" Tata Mc Graw Hill, New Delhi, 2003.
3. S.Salivahanan, A.Vallavaraj, C.Gnanapriya, Digital Signal Processing' Tata McGraw Hill, New Delhi, 2003.
4. Texas TMS 320C54X user manual (website)
5. J.R.Jhonson, Introduction to Digital Signal Processing Prentice Hall of India, 1989.

7. RTOS AND Vx: WORKS

UNIT I: REAL TIME OS-OVERVIEW

Introduction to Operating System – Functions of Operating System – Types of Operating Systems – Memory Management – Static and Dynamic partitions using MFT and MVT algorithms – Swapping, paging, segmentation – paged segmentations

Unit II: FILE MANAGEMENT SYSTEM OF OS

File systems – File structure – Disk structure – File allocation – contiguous and non contiguous allocation – free space management – disk scheduling algorithms – Process management Process - Threads – tasks – PCB –TSB – Process, status, short term – medium term – long term schedulers – CPU scheduling – algorithms – introduction to intel process communication using shared memory – pipes – message ques – semaphore – signal interrupt sockets – introduction to RTOS – real time systems – Hard real time systems – soft real time systems – micro knernel and Monolithic kernel architecture – features of RTOS- overview of some RTOS – LIKE Vx works,QNX,RT Linux,Window Ce,Symbian, Psos.

Unit III: Vx WORKS, MEMORY MANAGEMENT

Vx works and Tornodo, Features of IDE – Host Target Architecture – Project Management – Thread Scheduling algorithm – Inter task communication using shared memory – Pipes – Message Querues – Semaphores – Mutual exclusion

Unit IV: FILE FORMATS OF Vx WORKS

Hardware and software interrupt handling – RAM Disk – File systems – Using DOS file systems on RAM disks – I/O systems – Memory Management – WDT – Message logging – Overview of networking on Vx Works – Managing host table – Managing IP

Unit V: SOCKET PROGRAMMING

Address – Sockets – Accessing remote files using FTP, TFTP, RSH and NSF – configuring Vx Works as FTP server and FTP client – TFTP server and client – NFS server and NFS client – NFS Client Rlogin – Using Crosswind for Debugging – Using Wind View as a Runtime Analyzer – Using Browser and Winds, Using Integrated Simulator – Building Vx Works image – Creating a Boot image – Download and Booting Vx Works on the Target system

Reference Books:

1. LIU – Real time systems – Pearson Education
2. Lante – Real time system design and analysis – PHI
3. Vx Works – www.tornado.com

8. Molecular Physics

UNIT - I: Molecular Symmetry

Symmetry operation – symmetry elements – Different type of symmetry operations – symmetry point groups – Linear and non linear molecules – Representations of groups - Irreducible Representations and character – and character tables .

UNIT - II: Symmetry Aspects of molecular Orbital theory

General principles – the LACO approximation – the Huckel approximation – Bonding character of orbitals - symmetry factoring of secular equations – Transformation properties of Atomic orbitals – Hybridization schemes of and orbitals Hybrid orbitals as linear combinations of Atomic orbitals – Molecular orbital theory for AbB_n – types molecules .

UNIT - III: Central field approximation

Hartree Fock equation – The method of self consistent field – Hydrogen ion – Hydrogen molecule – covalent bond – Heitler – London theory – Approximate self – consistent molecular orbital theory I, II, III, and IV, Calculation of Equilibrium bond lengths by the CNDO Method .

UNIT - IV: Molecular vibrations

The symmetry of Normal vibrations – Determining the symmetry types of the Normal mode – Internal coordinates – symmetry coordinates - Normal coordinates – potential and kinetic energies in terms of symmetry coordinates – removal of redundant coordinates – application of group theory of Raman and I.R. activity .

UNIT - V: Potential Functions

The General Quadratic potential function – The approximation of central forces, valence forces - Modification of the simple force functions - Isotopic effect – Anharmonic terms in the potential energy – Quantum mechanical Resonance – characteristic values and characteristic vectors – symmetrization of the secular determinant – solution of the simultaneous equations – Matrix Iteration methods – Perturbation methods .

Books for study and References :

1. Chemical applications of group theory – Wiley Inter science F .A . Cotton .
2. infra red Raman spectroscopy – Herzberg.
3. Quantum chemistry A .K .Chandra
4. Molecular vibrations – E .B .Wilson , Decies and cross
5. Group theory application to molecular vibrations – PG Puranik
6. Approximate self – consistent molecular orbital theory II calculations with complete neglect of Differential over lap J . A . people and G .A .Segal J . Che . Phy . vol. 43 . (1965) .
7. Approximate self – consistent molecular orbital theory II Calculations with complete Neglect of Differential over lap J .A . people and G .A . segal J . che. Phy . Vol. 43 No .10
8. Approximate self – consistent molecular orbital theory III CNDD Results for AB,2 and AB,3 Systems .
9. Approximate self – consistent molecular orbital theory 4 Calculations on Molecules including the Elements sodium through chlorine D .P . Santry and G . A . segal J . chem. . phys . vol. 47 – 158 – 174 (1967) .
10. Calculation of Equilibrium bond lengths by the CNDO method G . A . Segal J . chem. . Phys . vol. 47 . 1876 – 1877 (1967) .

9. Thin Film Technology

UNIT - I: Preparation of Thin Films

Spray pyrolytic process – characteristic feature of the spray pyrolytic process – ion plating – Vacuum evaporation – Evaporation theory – The construction and use of vapour sources – sputtering Methods of sputtering – Reactive sputtering – RF sputtering - DC planar magnetron sputtering .

UNIT - II: (Thickness measurement and Nucleation and Growth in Thin Film)

Thickness measurement : electrical methods – optical interference methods – multiple beam interferometry – Fizeau – FECO methods – Quartz crystal thickness monitor .

Theories of thin film nucleation – Four stages of film growth incorporation of defects during growth .

UNIT - III: Electrical properties of metallic thin films

Sources of resistivity in metallic conductors – sheet resistance - Temperature coefficient of resistance (TCR) – influence of thickness on resistivity – Hall effect and magneto resistance – Annealing – Agglomeration and oxidation .

UNIT - IV: Transport properties of semiconducting and insulating Films

Semiconducting films ; Theoretical considerations - Experimental results – Photoconduction – Field effect thin films – transistors, Insulation films Dielectric properties – dielectric losses – Ohmic contacts – Metal – Insulator and Metal – metal contacts – DC and AC conduction mechanism .

UNIT - V: Optical properties of thin films and thin films solar cells

Thin films optics –Theory – Optical constants of thin films – Experimental techniques – Multilayer optical system – interference filters – Antireflection coating ,Thin films solar cells : Role, Progress , and production of thin solar cells – Photovoltaic parameter, Thin film silicon (Poly crystalline) solar cells : current status of bulk silicon solar cells – Fabrication technology – Photo voltaic performance : Emerging solar cells : GaAs and CuInSe .

Books for study

- 1 . Hand book of Thin films Technology : L I Maissel and R Clang .
- 2 . Thin film Phenomena : K L Chopra .
- 3 . physics of thin films, vol. 12 , Ed George Hass and others .
- 4 . Thin films solar cells – K L Chopra and S R Das .
- 5 . Thin films processes – J L vilsan

Books of Reference

- 1 . vacuum deposition of thin films – L Holland .
- 2 . The use of thin films in physical investigation – J C Anderson .
- 3 . Thin films technology – Berry, Koil and Harris
