CHOICE BASED CREDIT SYSTEM

B. SC. PROGRAM WITH ELECTRONICS

Details of Courses Under CBCS for B.Sc. with Electronics as one subject.

Course	***Credits**	
	Theory+ Practical	Theory+Tutorials
I. Core Course **(12 Papers)** 04 Courses from each of the 03 disciplines of choice	12X4= 48	12X5=60
Core Course Practical / Tutorial* **(12 Practical/ Tutorials*)** 04 Courses from each of the 03 Disciplines of choice	12X2=24	12X1=12
II. Elective Course **(6 Papers)** Two papers from each discipline of choice including paper of interdisciplinary nature.	6x4=24	6X5=30
Elective Course Practical / Tutorials* **(6 Practical / Tutorials*)** Two Papers from each discipline of choice including paper of interdisciplinary nature	6 X 2=12	6X1=6
III. Ability Enhancement Courses		
1**. Ability Enhancement Compulsory** **(2 Papers of 2 credits each)** **Environmental Science** **English/MIL Communication**	2 X 2=4	2X2=4
2**. Skill Enhancement Course** **(Skill Based)** **(4 Papers of 2 credits each)**	4 X 2=8	4 X 2=8
	Total credit= 120	**Total credit= 120**

- **Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester**

Institute should evolve a system/policy about ECA/ General Interest/Hobby/ Sports/ NCC/NSS/related courses on its own.

***Wherever there is a practical there will be no tutorial & vice-versa. The size of group for practical papers is recommended to be maximum of 12 to 15 students.**

Scheme for choice based credit system in B. Sc. Program with Electronics as one subject

	CORE COURSE (12)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective DSE (6)
I	Network Analysis and Analog Electronics	(English/MIL Communication)/ Environmental Science		
	DSC- 2 A			
	DSC- 3 A			
II	Linear and Digital Integrated Circuits	Environmental Science /(English/MIL Communication)		
	DSC- 2 B			
	DSC- 3 B			
III	Communication Electronics		SEC-1	
	DSC- 2 C			
	DSC- 3 C			
IV	Microprocessor and Microcontrollers		SEC -2	
	DSC- 2 D			
	DSC- 3 D			
V			SEC -3	DSE-1 A
				DSE-2 A
				DSE-3 A
VI			SEC -4	DSE-1 B
				DSE-2 B
				DSE-3 B

B. Sc. Program with Electronics as one subject

Semester	COURSE OPTED	COURSE NAME	Credits
I	Ability Enhancement Compulsory Course-I	English communications/ Environmental Science	2
	Core course-I	Networks Analysis & Analog Electronics	4
	Core Course-I Practical/Tutorial*	Networks Analysis and Analog Electronics Lab	2
	Core course-II	DSC 2A	6
	Core Course-III	DSC 3A	6
II	Ability Enhancement Compulsory Course-II	English communications/ Environmental Science	2
	Core course-IV	Linear and Digital Integrated Circuits	4
	Core Course-IV Practical/Tutorial*	Linear & Digital Integrated Circuits Lab	2
	Core course-V	DSC 2B	6
	Core Course-VI	DSC 3B	6
III	Core course-VII	Communication Electronics	4
	Core course-VII Practical/Tutorial*	Communication Electronics Lab	2
	Core course-VIII	DSC 2C	6

	Core Course-IX	**DSC 3C**	**6**
	Skill Enhancement Course -1	**SEC-1**	**2**
IV	**Core course-X**	**Microprocessor and Microcontroller**	**4**
	Course-X Practical/Tutorial*	**Microprocessor& Microcontroller Lab**	**2**
	Core course-XI	**DSC 2D**	**6**
	Core course-XII	**DSC 3D**	**6**
	Skill Enhancement Course -2	**SEC -2**	**2**
V	**Skill Enhancement Course -3**	**SEC -3**	**2**
	Discipline Specific Elective -1*	**DSE-1A (for Subject 1-Electronics)**	**6**
	Discipline Specific Elective -2	**DSE-2A (for subject-2)**	**6**
	Discipline Specific Elective -3	**DSE-3A (for subject-3)**	**6**
VI	**Skill Enhancement Course -4**	**SEC -4**	**2**
	Discipline Specific Elective -4*	**DSE-1B (for subject 1-Electronics)**	**6**
	Discipline Specific Elective -5	**DSE-2B (for subject-2)**	**6**
	Discipline Specific Elective-6	**DSE-3B (for subject-3)**	**6**
Total Credits			**120**

***Wherever there is a practical there will be no tutorial and vice-versa. The size of group for practical papers is recommended to be maximum of 12 to 15 students.**

B.Sc. Program Electronics

Core papers Electronics (Credit: 06 each) (CP 1-4):

1. Network Analysis and Analog Electronics (4) + Lab (4)
2. Linear and Digital Integrated Circuits (4) + Lab (4)
3. Communication Electronics (4) + Lab (4)
4. Microprocessor and microcontrollers (4) + Lab (4)

Discipline Specific (Electronics) Elective papers (Credit: 06 each)
(DSE 1, DSE 2): Choose any 2 (one in each semester).

Odd semester Options:

1. Semiconductor Devices Fabrication (4) + Lab (4)
2. Electronic Instrumentation (4) + Lab (4)
3. Digital Signal Processing (4) + Lab (4)

Even semester Options:

4. Verilog and FPGA based system Design (4) + Lab (4)
5. Photonic devices and Power Electronics (4) + Lab (4)
6. Antenna Theory and wireless Network (5) + Tutorial (1)
7. Dissertation

Skill Enhancement Course (any four) (Credit: 02 each)- SEC 1 to SEC 4

1. Computational Physics Skills
2. Electrical circuits and Network Skills
3. Renewable Energy and Energy harvesting
4. Engineering design and prototyping
5. Applied Optics
6. Weather Forecasting

Semester I

ELECTRONICS-DSC 1A: NETWORK ANALYSIS AND ANALOG ELECTRONICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Circuit Analysis: Concept of Voltage and Current Sources. Kirchhoff's Current Law, Kirchhoff's Voltage Law. Mesh Analysis. Node Analysis. Star and Delta networks, Star-Delta Conversion. Principal of Duality. Superposition Theorem. Thevenin's Theorem. Norton's Theorem. Reciprocity Theorem. Maximum Power Transfer Theorem. Two Port Networks: h, y and z parameters and their conversion. **(14 Lectures)**

Junction Diode and its applications: PN junction diode (Ideal and practical)-constructions, Formation of Depletion Layer, Diode Equation and I-V characteristics. Idea of static and dynamic resistance, dc load line analysis, Quiescent (Q) point. Zener diode, Reverse saturation current, Zener and avalanche breakdown. Qualitative idea of Schottky diode. Rectifiers- Half wave rectifier, Full wave rectifiers (center tapped and bridge), circuit diagrams, working and waveforms, ripple factor and efficiency. Filter- Shunt capacitor filter, its role in power supply, output waveform, and working. Regulation- Line and load regulation, Zener diode as voltage regulator, and explanation for load and line regulation. **(18 Lectures)**

Bipolar Junction Transistor: Review of the characteristics of transistor in CE and CB configurations, Regions of operation (active, cut off and saturation), Current gains α and β. Relations between α and β. dc load line and Q point. **(5 Lectures)**

Amplifiers: Transistor biasing and Stabilization circuits- Fixed Bias and Voltage Divider Bias. Thermal runaway, stability and stability factor S. Transistor as a two port network, h-parameter equivalent circuit. Small signal analysis of single stage CE amplifier. Input and Output impedance, Current and Voltage gains. Class A, B and C Amplifiers.
(10 Lectures)

Cascaded Amplifiers: Two stage RC Coupled Amplifier and its Frequency Response.
(2 Lectures)

Feedback in Amplifiers: Concept of feedback, negative and positive feedback, advantages of negative feedback (Qualitative only). **(2 Lectures)**

Sinusoidal Oscillators: Barkhausen criterion for sustained oscillations. Phase shift and Colpitt's oscillator. Determination of Frequency and Condition of oscillation.
(5 Lectures)

Unipolar Devices: JFET. Construction, working and I-V characteristics (output and

transfer), Pinchoff voltage. UJT, basic construction, working, equivalent circuit and I-V characteristics. **(4 Lectures)**

Reference Books:

- Electric Circuits, S. A. Nasar, Schaum's outline series, Tata McGraw Hill (2004)
- Electrical Circuits, M. Nahvi & J. Edminister, Schaum's Outline Series, Tata McGraw-Hill (2005)
- Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
- Network, Lines and Fields, J.D.Ryder, Prentice Hall of India.
- Electronic Devices and Circuits, David A. Bell, 5th Edition 2015, Oxford University Press.
- Electronic Circuits: Discrete and Integrated, D.L. Schilling and C. Belove, Tata McGraw Hill
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
- J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill (2001)
- J. J. Cathey, 2000 Solved Problems in Electronics, Schaum's outline Series, Tata McGraw Hill (1991)

ELECTRONICS LAB: DSC 1A LAB: NETWORK ANALYSIS AND ANALOG ELECTRONICS LAB

60 Periods

AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING BESIDES #1

1. To familiarize with basic electronic components (R, C, L, diodes, transistors), digital Multimeter, Function Generator and Oscilloscope.
2. Measurement of Amplitude, Frequency & Phase difference using Oscilloscope.
3. Verification of (a) Thevenin's theorem and (b) Norton's theorem.
4. Verification of (a) Superposition Theorem and (b) Reciprocity Theorem.
5. Verification of the Maximum Power Transfer Theorem.
6. Study of the I-V Characteristics of (a) p-n junction Diode, and (b) Zener diode.
7. Study of (a) Half wave rectifier and (b) Full wave rectifier (FWR).
8. Study the effect of (a) C- filter and (b) Zener regulator on the output of FWR.
9. Study of the I-V Characteristics of UJT and design relaxation oscillator..
10. Study of the output and transfer I-V characteristics of common source JFET.
11. Study of Fixed Bias and Voltage divider bias configuration for CE transistor.
12. Design of a Single Stage CE amplifier of given gain.
13. Study of the RC Phase Shift Oscillator.
14. Study the Colpitt`s oscillator.

Reference Books:

- Electrical Circuits, M. Nahvi and J. Edminister, Schaum's Outline Series, Tata McGraw-Hill (2005)
- Networks, Lines and Fields, J.D.Ryder, Prentice Hall of India.
- J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill (2001)
- Allen Mottershead, Electronic Devices and Circuits, Goodyear Publishing Corporation.

Semester II

ELECTRONICS-DSC 1B: LINEAR AND DIGITAL INTEGRATED CIRCUITS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Operational Amplifiers (Black box approach): Characteristics of an Ideal and Practical Operational Amplifier (IC 741), Open and closed loop configuration, Frequency Response. CMRR. Slew Rate and concept of Virtual Ground. (**5 Lectures**)

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Summing and Difference Amplifier, (3) Differentiator, (4) Integrator, (5) Wein bridge oscillator, (6) Comparator and Zero-crossing detector, and (7) Active low pass and high pass Butterworth filter (1^{st} order only). (**12 Lectures**)

Number System and Codes: Decimal, Binary, Octal and Hexadecimal number systems, base conversions. Representation of signed and unsigned numbers, BCD code. Binary, octal and hexadecimal arithmetic; addition, subtraction by 2's complement method, multiplication. (**9 Lectures**)

Logic Gates and Boolean algebra: Truth Tables of OR, AND, NOT, NOR, NAND, XOR, XNOR, Universal Gates, Basic postulates and fundamental theorems of Boolean algebra. (**4 Lectures**)

Combinational Logic Analysis and Design: Standard representation of logic functions (SOP and POS), Minimization Techniques (Karnaugh map minimization up to 4 variables for SOP). (**5 Lectures**)

Arithmetic Circuits: Binary Addition. Half and Full Adder. Half and Full Subtractor, 4-bit binary Adder/Subtractor. (**5 Lectures**)

Data processing circuits: Multiplexers, De-multiplexers, Decoders, Encoders. (**4 Lectures**)

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. Master-slave JK Flip-Flop. (**6 Lectures**)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). (2 **Lectures**)

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. (**4 Lectures**)

D-A and A-D Conversion: 4 bit binary weighted and R-2R D-A converters, circuit and working. Accuracy and Resolution. A-D conversion characteristics, successive approximation ADC. (Mention of relevant ICs for all). (**4 Lectures**)

Reference Books:

- OP-Amps and Linear Integrated Circuit, R.A. Gayakwad, 4th edition, 2000, Prentice Hall
- Operational Amplifiers and Linear ICs, David A. Bell, 3rd Edition, 2011, Oxford University Press.
- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Thomas L. Flyod, Digital Fundamentals, Pearson Education Asia (1994)
- Digital Principles, R.L.Tokheim, Schaum's outline series, Tata McGraw- Hill (1994)

ELECTRONICS LAB- DSC 1B LAB: LINEAR AND DIGITAL INTEGRATED CIRCUITS LAB
60 Periods

At least 04 experiments each from section A, B and C
Section-A: Op-Amp. Circuits (Hardware design)

1. To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain.
2. (a) To design inverting amplifier using Op-amp (741, 351) and study its frequency response.

   (b) To design non-inverting amplifier using Op-amp (741, 351) and study frequency response.
3. (a) To add two dc voltages using Op-Amp in inverting and non-inverting mode.

   (b) To study the zero-crossing detector and comparator.
4. To design a precision Differential amplifier of given I/O specification using Op-Amplifier.

5. To investigate the use of an op-amp as an Integrator.
6. To investigate the use of an op-amp as a Differentiator.
7. To design a Wien bridge oscillator for given frequency using an Op-Amplifier.
8. To design a circuit to simulate the solution of simultaneous equation and $1^{st}/2^{nd}$ order differential equation.
9. Design a Butterworth Low Pass active Filter (1^{st} order) and study frequency response.
10. Design a Butterworth High Pass active Filter (1^{st} order) and study frequency response.
11. Design a digital to analog converter (DAC) of given specifications.

Section-B: Digital circuits (Hardware design)

1. (a) To design a combinational logic system for a specified Truth Table.

   (b) To convert Boolean expression into logic circuit & design it using logic gate ICs.

   (c) To minimize a given logic circuit.
2. Half Adder and Full Adder.
3. Half Subtractor and Full Subtractor.
4. 4 bit binary adder and adder-subtractor using Full adder IC.
5. To design a seven segment decoder.
6. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
7. To build JK Master-slave flip-flop using Flip-Flop ICs.
8. To build a Counter using D-type/JK Flip-Flop ICs and study timing diagram.
9. To make a Shift Register (serial-in and serial-out) using D-type/JK Flip-Flop ICs.

Section-C: ***SPICE/MULTISIM simulations for electronic circuits and devices***

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits.
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain.
4. Design and Verification of op-amp as integrator and differentiator.
5. Design the 1^{st}order active low pass and high pass filters of given cutoff frequency.
6. Design a Wein`s Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flop`s using NAND Gates.
8. Design 4-bit asynchronous counter using Flip-Flop ICs.
9. Design the CE amplifier of a given gain and its frequency response.

Reference Books

- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th

Edition, 2011, Tata McGraw.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
- R. L. Tokheim, Digital Principles, Schaum's Outline Series, Tata McGraw- Hill (1994).
- Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill.

Semester III

ELECTRONICS- DSC 1C: COMMUNICATION ELECTRONICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio. **(8 Lectures)**

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver. **(12 Lectures)**

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing. **(9 Lectures)**

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). **(10 Lectures)**

Introduction to Communication and Navigation systems:
Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. **(10 Lectures)**

Mobile Telephony System – Basic concept of mobile communication, frequency bands

used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). **(10 Lectures)**

GPS navigation system (qualitative idea only) **(1 Lecture)**

Reference Books:

- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
- Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
- Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
- Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
- Communication Systems, S. Haykin, 2006, Wiley India
- Electronic Communication system, Blake, Cengage Learning, 5th edition.
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

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ELECTRONICS LAB-DSC 1C LAB: COMMUNICATION ELECTRONICS LAB

60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

Reference Books:

- Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
- Electronic Communication system, Blake, Cengage, 5th edition.

Semester IV

ELECTRONICS-DSC 1D: MICROPROCESSOR AND MICROCONTROLLER
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Microcomputer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. **(5 Lectures)**

8085 Microprocessor Architecture: Main features of 8085. Block diagram. Pin-out diagram of 8085. Data and address buses. Registers. ALU. Stack memory. Program counter. **(8 Lectures)**

8085 Programming : Instruction classification, Instructions set (Data transfer including stacks. Arithmetic, logical, branch, and control instructions). Subroutines, delay loops. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. Hardware and software interrupts. **(10 Lectures)**

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. **(12 Lectures)**

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation. **(5 Lectures)**

8051 Programming: 8051 addressing modes and accessing memory locations using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay and I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions. **(15 Lectures)**

Introduction to embedded system: Embedded systems and general purpose computer systems. Architecture of embedded system. Classifications, applications and purpose of embedded systems. **(5 Lectures)**

Reference Books:

- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
- Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.

- Microprocessor and Microcontrollers, N. Senthil Kumar, 2010, Oxford University Press
- 8051 microcontrollers, Satish Shah, 2010, Oxford University Press.
- Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India
- Introduction to embedded system, K.V. Shibu, 1st edition, 2009, McGraw Hill
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

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ELECRONICS LAB-DSC 1D LAB: MICROPROCESSOR AND MICROCONTROLLER LAB
60 Periods

At least 06 experiments each from Section-A and Section-B

Section-A: Programs using 8085 Microprocessor

1. Addition and subtraction of numbers using direct addressing mode
2. Addition and subtraction of numbers using indirect addressing mode
3. Multiplication by repeated addition.
4. Division by repeated subtraction.
5. Handling of 16-bit Numbers.
6. Use of CALL and RETURN Instruction.
7. Block data handling.
8. Other programs (e.g. Parity Check, using interrupts, etc.).

Section-B: Experiments using 8051 microcontroller:

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's .
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.

10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement & display on LCD

Reference Books:

- Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
- Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill
- The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
- 8051 microcontrollers, Satish Shah, 2010, Oxford University Press.
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

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Discipline Specific Elective (DSE)

Select two papers

ELECTRONICS- DSE: SEMICONDUCTOR DEVICES FABRICATION

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Introduction: Review of energy bands in materials. Metal, Semiconductor and Insulator. Doping in Semiconductors, Defects: Point, Line, Schottky and Frenkel. Single Crystal, Polycrystalline and Amorphous Materials. Czochralski technique for Silicon Single Crystal Growth. Silicon Wafer Slicing and Polishing. **(5 Lectures)**

Thin Film Growth Techniques and Processes: Vacuum Pumps: Primary Pump (Mechanical) and Secondary Pumps (Diffusion, Turbo-molecular, Cryopump, Sputter - Ion)– basic working principle, Throughput and Characteristics in reference to Pump Selection. Vacuum Gauges (Pirani and Penning). **(6 Lectures)**

Sputtering, Evaporation (Thermal, electron-Beam, Pulse Laser Deposition (PLD), Chemical Vapor Deposition (CVD). Epitaxial Growth, Deposition by Molecular Beam Epitaxy (MBE). **(9 Lectures)**

Thermal Oxidation Process (Dry and Wet) Passivation. Metallization. Diffusion of Dopants. Diffusion Profiles. Ion implantation. **(5 Lectures)**

Semiconductor Devices: Review of p-n Junction diode, Metal-Semiconductor junction, Metal-Oxide-Semiconductor (MOS) capacitor and its C-V characteristics, MOSFET (enhancement and depletion mode) and its high Frequency limit. Microwave Devices: Tunnel diode. **(6 Lectures)**

Memory Devices: Volatile Memory: Static and Dynamic Random Access Memory (RAM), Complementary Metal Oxide Semiconductor (CMOS) and NMOS, Non-Volatile - NMOS (MOST, FAMOS), Ferroelectric Memories, Optical Memories, Magnetic Memories, Charge Coupled Devices (CCD). **(10 Lectures)**

VLSI Processing: Introduction of Semiconductor Process Technology, Clean Room Classification, Line width, Photolithography: Resolution and Process, Positive and Negative Shadow Masks, Photoresist, Step Coverage, Developer. Electron Beam Lithography. Idea of Nano-Imprint Lithography. Etching: Wet Etching. Dry etching (RIE and DRIE). Basic Fabrication Process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology. Wafer Bonding, Wafer Cutting, Wire bonding and Packaging issues (Qualitative idea). **(12 Lectures)**

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, Materials selection for MEMS Devices, Selection of Etchants, Surface and Bulk Micromachining, Sacrificial Subtractive Processes, Additive Processes, Cantilever, Membranes. General Idea MEMS based Pressure, Force, and Capacitance Transducers. **(7 Lectures)**

Reference Books:

- Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
- Handbook of Thin Film Technology, Leon I. Maissel and Reinhard Glang.
- Fundamentals of Semiconductor Fabrication, S.M. Device and G. S. May, John-Wiley and Sons, Inc.
- The science and Engineering of Microelectronics Fabrication, Stephen A. Champbell, 2010, Oxford University Press.
- Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons
- VLSI Fabrication Principles (Si and GaAs), S.K. Gandhi, John Wiley & Sons, Inc.

PRACTICALS- DSE LAB: SEMICONDUCTOR DEVICES FABRICATION LAB

60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING

1. Fabrication of alloy p-n Junction diode and study its I-V Characteristics.
2. Study the output and transfer characteristics of MOSFET.
3. To design and plot the static & dynamic characteristics of digital CMOS inverter.
4. Create vacuum in a small tube (preferably of different volumes) using a Mechanical rotary pump and measure pressure using vacuum gauges.
5. Deposition of Metal thin films/contacts on ceramic/thin using Thermal Evaporation and study IV characteristics.
6. Selective etching of Different Metallic thin films using suitable etchants of different concentrations.

7. Wet chemical etching of Si for MEMS applications using different concentration of etchant.
8. Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75).
9. Quantum efficiency of CCDs.
10. To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150^{o}C) by four-probe method.
11. To fabricate a ceramic and study its capacitance using LCR meter.
12. To fabricate a thin film capacitor using dielectric thin films and metal contacts and study its capacitance using LCR meter.
13. Study the linearity characteristics of

    (a) Pressure using capacitive transducer

    (b) Distance using ultrasonic transducer

Reference Books:

- Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
- Handbook of Thin Film Technology, Leon I. Maissel and Reinhard Glang.
- The science and Engineering of Microelectronics Fabrication, Stephen A. Champbell, 2010, Oxford University Press.
- VLSI Fabrication Principles (Si and GaAs), S.K. Gandhi, John Wiley & Sons, Inc.

ELECTRONICS-DSE: ELECTRONIC INSTRUMENTATION
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Shielding and grounding. Electromagnetic Interference. **(3 Lectures)**

Basic Measurement Instruments: DC measurement-ammeter, voltmeter, ohm meter, AC measurement, Digital voltmeter systems (integrating and non-integrating). Digital Multimeter; Block diagram principle of measurement of I, V, C. Accuracy and resolution of measurement. **Measurement of Impedance-** A.C. bridges, Measurement of Self Inductance (Anderson's bridge), Measurement of Capacitance (De Sauty's bridge), Measurement of frequency (Wien's bridge). **(12 Lectures)**

Power supply: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators (78XX and 79XX), Line and load regulation, Short circuit protection. Idea of switched mode power supply (SMPS) & uninterrupted power supply(UPS). **(4 Lectures)**

Oscilloscope: Block Diagram, CRT, Vertical Deflection, Horizontal Deflection. Screens for CRT, Oscilloscope probes, measurement of voltage, frequency and phase by Oscilloscope. Digital Storage Oscilloscope. LCD display for instruments. **(10 Lectures)**

Multivibrators (IC 555): Block diagram, Astable & Monostable multivibrator circuits. **Phase Locked Loop (PLL)**: Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor), lock and capture. Basic idea of PLL IC (565 or 4046). Lock-in-amplifier (qualitative only). **(11 Lectures)**

Signal Generators: Function generator, Pulse Generator(qualitative only). **(3 Lectures)**

Virtual Instrumentation: Introduction, Interfacing techniques (RS 232, GPIB, USB). Idea about Audrino microcontroller & interfacing software like lab View). (**5 Lectures)**

Transducers: Classification of transducers, Basic requirement/characteristics of transducers, Active and Passive transducers, Resistive (Potentiometer- Theory, temperature compensation and applications), Capacitive (variable air gap type), Inductive (LVDT) and piezoelectric transducers. Measurement of temperature(RTD, semiconductor IC sensors), Light transducers (photo resistors & photovoltaic cells). **(12 Lectures)**

Reference Books:

- W.D. Cooper and A. D. Helfrick, Electronic Instrumentation and Measurement Techniques, Prentice Hall (2005).
- E.O. Doebelin, Measurement Systems: Application and Design, McGraw Hill Book - fifth Edition (2003).
- David A. Bell, Electronic Devices and Circuits, Oxford University Press (2015).
- Alan S. Morris, "Measurement and Instrumentation Principles", Elsevier (Butterworth Heinmann-2008).
- S. Rangan, G. R. Sarma and V. S. Mani, Instrumentation Devices and Systems, Tata Mcgraw Hill (1998).

PRACTICALS -DSE LAB: ELECTRONIC INSTRUMENTATION LAB

60 Periods

AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING

1. Measurement of resistance by Wheatstone bridge and measurement of bridge sensitivity.
2. Measurement of Capacitance by De Sauty's bridge
3. To determine the Characteristics of resistance transducer - Strain Gauge (Measurement of Strain using half and full bridge.)
4. To determine the Characteristics of LVDT.
5. To determine the Characteristics of Thermistors and RTD.
6. Measurement of temperature by Thermocouples.
7. Design a regulated power supply of given rating (5 V or 9V).

8. To design an Astable Multivibrator of given specification using IC 555 Timer.
9. To design a Monostable Multivibrator of given specification using IC 555 Timer.
10. To design and study the Sample and Hold Circuit.
11. To plot the frequency response of a microphone.
1. Glow an LED via USB port of PC.
12. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

Reference Books:

- W.D. Cooper and A. D. Helfrick, Electronic Instrumentation and Measurement Techniques, Prentice Hall (2005).
- David A. Bell, Electronic Instrumentation & Measurements, Prentice Hall (2013)
- S. Rangan, G. R. Sarma and V. S. Mani, Instrumentation Devices and Systems, Tata Mcgraw Hill (1998).
- Basic Electronics:A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1990, Mc-Graw Hill

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ELECTRONICS-DSE: DIGITAL SIGNAL PROCESSING

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals. This paper also highlights the concept of filters and realization of Digital Filters. At the end of the syllabus, students will develop the understanding of Discrete and fast Fourier Transform..

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response. **(10 Lectures)**

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. **The *z*-Transform:** Bilateral (Two-Sided) *z*-Transform, Inverse *z*-Transform, Relationship Between *z*-Transform and Discrete-Time Fourier Transform, *z*-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the *z*-Domain; Power Series Expansion Method (or Long Division

Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations. **(15 Lectures)**

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters. **(5 Lectures)**

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing. **(10 Lectures)**

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (*WN*), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms. **(5 Lectures)**

Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.

Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method. **(15 Lectures)**

Reference Books:

- Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
- Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
- Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
- Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
- Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.

PRACTICAL-DSE LAB: DIGITAL SIGNAL PROCESSING LAB
60 Periods

At least 06 experiments from the following using Scilab. Introduction to Numerical computation software Scilab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \leq n \leq 50$.

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5

$$x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \leq n \leq N \\ 0 & otherwise \end{cases}$$

3. An LTI system is specified by the difference equation

$$y(n) = 0.8y(n-1) + x(n)$$

(a) Determine $H(e^{jw})$

(b) Calculate and plot the steady state response $y_{ss}(n)$ to

$$x(n) = \cos(0.5\pi n)u(n)$$

4. Given a casual system

$$y(n) = 0.9y(n-1) + x(n)$$

(a) Find $H(z)$ and sketch its pole-zero plot

(b) Plot the frequency response $|H(e^{jw})|$ and $\angle H(e^{jw})$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t$. The sampling frequency is $f_s = 500\,Hz$. Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let $x(n)$ be a 4-point sequence:

$$x(n) = \underset{\uparrow}{\{1,1,1,1\}} = \begin{cases} 1 & 0 \leq n \leq 3 \\ 0 & otherwise \end{cases}$$

Compute the DTFT $X(e^{jw})$ and plot its magnitude

(a) Compute and plot the 4 point DFT of $x(n)$

(b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)

(c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros)

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences,

$$x(n) = \underset{\uparrow}{\{1,2,2,1\}}$$

$$h(n) = \underset{\uparrow}{\{1,-1,-1,1\}}$$

Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:
passband edge $F_p = 2\ KHz$
stopband edge $F_s = 5\ KHz$
Passband attenuation $A_p = 2\ dB$
Stopband attenuation $A_s = 42\ dB$
Sampling frequency $F_s = 20\ KHz$

10. The frequency response of a linear phase digital differentiator is given by
$$H_d(e^{jw}) = jwe^{-j\tau w} \qquad |w| \leq \pi$$
Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

Reference Books:

- Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
- Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.
- Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
- Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.

ELECTRONICS-DSE: VERILOG AND FPGA BASED SYSTEM DESIGN

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits. Evolution of Programmable logic devices such as PAL, PLA and GAL is explained. At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices. (**20 lectures**)

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan. (**20 lectures**)

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational & sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog. (**20 lectures**)

Reference Books:

- LizyKurien and Charles Roth. *Principles of Digital Systems Design and VHDL.*Cengage Publishing. ISBN-13: 978-8131505748
- Ming-Bo Lin. *Digital System Designs and Practices: Using Verilog HDL and FPGAs.* Wiley India Pvt Ltd. ISBN-13: 978-8126536948
- Zainalabedin Navabi. *Verilog Digital System Design.* TMH; 2nd edition. ISBN-13: 978-0070252219
- Wayne Wolf. *FPGA Based System Design.* Pearson Education.
- S. K. Mitra, Digital Signal processing, McGraw Hill, 1998
- VLSI design, Debaprasad Das, 2nd Edition, 2015, Oxford University Press.
- D.J. Laja and S. Sapatnekar, Designing Digital Computer Systems with Verilog, Cambridge University Press, 2015.

PRACTICALS-DSE LAB: VERILOG AND FPGA LAB
60 Periods

AT LEAST 08 EXPERIMENTS FROM FOLLOWING.

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4 bit Adder.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs)
8. 3-bit Ripple counter
9. To design and study switching circuits (LED blink shift)
10. To design traffic light controller.
11. To interface a keyboard
12. To interface a LCD using FPGA

13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

Reference Books

- W.Wolf, FPGA- based System Design, Pearson, 2004
- U. Meyer Baese, Digital Signal Processing with FPGAs, Springer, 2004
- S. Palnitkar, Verilog HDL– A Guide to Digital Design & Synthesis, Pearson, 2003
- Verilog HDL primer- J. Bhasker. BSP, 2003 II edition

ELECTRONICS- DSE: PHOTONIC DEVICES AND POWER ELECTRONICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

UNIT-I: PHOTONIC DEVICES

Classification of photonic devices. Interaction of radiation and matter, Radiative transition and optical absorption. Light Emitting Diodes- Construction, materials and operation. Semiconductor Laser- Condition for amplification, laser cavity, hetero-structure and quantum well devices. Charge carrier and photon confinement, line shape function. Threshold current. Laser diode. **(12 Lectures)**

Photodetectors: Photoconductor. Photodiodes (p-i-n, avalanche) and Photo transistors, quantum efficiency and responsivity. Photomultiplier tube. **(5 Lectures)**

Solar Cell: Construction, working and characteristics **(2 Lectures)**

LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays. **(4 Lectures)**

Introduction to Fiber Optics: Evolution of fiber optic system- Element of an Optical Fiber Transmission link- Ray Optics-Optical Fiber Modes and Configurations -Mode theory of Circular Wave guides- Overview of Modes-Key Modal concepts- Linearly Polarized Modes -Single Mode Fibers-Graded Index fiber structure. **(13 Lectures)**

UNIT-II: **POWER ELECTRONICS**

Power Devices: Need for semiconductor power devices, Power MOSFET (Qualitative). Introduction to family of thyristors. Silicon Controlled Rectifier (SCR)- structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Gate-triggering circuits. Diac and Triac- Basic structure, working and V-I characteristics. Application of Diac as a triggering device for Triac. **(10 Lectures)**

Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics,

switching characteristics, device limitations and safe operating area (SOA). **(2 Lectures)**

Applications of SCR: Phase controlled rectification, AC voltage control using SCR and Triac as a switch. Power Invertors- Need for commutating circuits and their various types, dc link invertors, Parallel capacitor commutated invertors, Series Invertor, limitations and its improved versions, bridge invertors. **(12 Lectures)**

Reference Books:

- Optoelectronics, J. Wilson and J.F.B. Hawkes, Prentice Hall India (1996)
- Optoelectronics and Photonics, S.O. Kasap, Pearson Education (2009)
- Electronic Devices and Circuits, David A. Bell, 2015, Oxford University Press.
- Introduction to fiber optics, AK Ghatak & K Thyagarajan, Cambridge University Press (1998)
- Power Electronics, P.C. Sen, Tata McGraw Hill
- Power Electronics, M.D. Singh & K.B. Khanchandani, Tata McGraw Hill

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PRACTICALS -DSE-1 LAB: PHOTONIC DEVICES AND POWER ELECTRONICS LAB

60 Periods

AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING

1. To determine wavelength of sodium light using Michelson's Interferometer.
2. Diffraction experiments using a laser.
3. Study of Electro-optic Effect.
4. To determine characteristics of (a) LEDs, (b) Photo voltaic cell and (c) Photo diode.
5. To study the Characteristics of LDR and Photodiode with (i) Variable Illumination intensity, and (ii) Linear Displacement of source.
6. To measure the numerical aperture of an optical fiber.
7. Output and transfer characteristics of a power MOSFET.
8. Study of I-V characteristics of SCR
9. SCR as a half wave and full wave rectifiers with R and RL loads.
10. AC voltage controller using TRIAC with UJT triggering.
11. Study of I-V characteristics of DIAC
12. Study of I-V characteristics of TRIAC

Reference Books:

- Introduction to fiber optics, AK Ghatak and K Thyagarajan, Cambridge University Press (1998)
- Power Electronics, M.D. Singh & K.B. Khanchandani, Tata McGraw Hill

- Power Electronics Circuits, Devices & Applications, 3rd Edn., M.H.Rashid, Pearson Education
- A Textbook of Electrical Technology,Vol-II, B.L.Thareja, A.K.Thareja, S.Chand.

ELECTRONICS-DSE: ANTENNA THEORY AND WIRELESS NETWORKS

(Credits: Theory-05, Tutorial-01)

Theory: 75 Lectures

ANTENNA THEORY:

Introduction: Antenna as an element of wireless communication system, Antenna radiation mechanism, Types of Antennas, Fundamentals of EMFT: Maxwell's equations and their applications to antennas. **(7 Lectures)**

Antenna Parameters: Antenna parameters: Radiation pattern (polarization patterns, Field and Phase patterns), Field regions around antenna, Radiation intensity, Beam width, Gain, Directivity, Polarization, Bandwidth, Efficiency and Antenna temperature.

(9 Lectures)

Antenna as a Transmitter/Receiver: Effective Height and Aperture, Power delivered to antenna, Input impedance. Radiation from an infinitesimal small current element, Radiation from an elementary dipole (Hertzian dipole), Reactive, Induction and Radiation fields, Power density and radiation resistance for small current element and half wave dipole antenna. **(12 Lectures)**

Radiating wire Structures (Qualitative idea only): Monopole, Dipole, Folded dipole, Loop antenna and Biconical broadband Antenna. Basics of Patch Antenna and its design. Examples of Patch antenna like bowtie, sectoral, fractal, etc. **(6 Lectures)**

Propagation of Radio Waves: Different modes of propagation: Ground waves, Space waves, Space Wave propagation over flat and curved earth, Optical and Radio Horizons, Surface Waves and Troposphere waves, Ionosphere, Wave propagation in the Ionosphere. Critical Frequency, Maximum usable frequency (MUF), Skips distance. Virtual height. Radio noise of terrestrial and extraterrestrial origin. Elementary idea of propagation of waves used in terrestrial mobile communications. **(9 Lectures)**

WIRELESS NETWORKS:

Introduction: History of wireless communication, Wireless Generation and Standards, Cellular and Wireless Systems, Current Wireless Systems, Cellular Telephone Systems, Wide Area Wireless Data Services, Broadband Wireless Access, Satellite Networks, Examples of Wireless Communication Systems. Idea about Global Mobile communication system. **(10 Lectures)**

Modern Wireless Communication Systems: Second Generation (2G) Cellular Networks, Third Generation (3G) Wireless Networks, Wireless Local Loop (WLL), Wireless Local Area Networks (WLANs), Bluetooth and Personal Area Networks (PANs). Idea about Wi-Fi, 4G and LTE, and 5G. **(10 Lectures)**

Cellular Concept and System Design Fundamentals: Cellular Concept and Cellular System Fundamentals, Frequency Reuse, Channel Assignment Strategies, Handoff strategies, Interference and System Capacity, Trunking and Grade of Service. Improving Coverage & Capacity in Cellular Systems. Cell Splitting and Sectoring. Cellular Systems design Considerations (Qualitative idea only). **(12 Lectures)**

Reference Books:

- Ballanis, Antenna Theory, John Wiley & Sons, (2003) 2nd Ed.
- Jordan and Balmain, E. C., Electro Magnetic Waves and Radiating Systems, PHI, 1968 Reprint (2003) 3rd Ed.
- Andrea Goldsmith, Wirelerss communications, (2015) Cambridge University Press
- D. Tse and P. Viswanathan, Fundamentals of Wireless Communication, (2014) Cambridge University Press
- Wireless communication and Networks, Upena Dala, 2015, Oxford University Press.
- Haykin S. & Moher M., Modern Wireless Communication, Pearson, (2005) 3rd Ed.
- Lee, William C.Y., Mobile Communciation Design and Fundamentals, (1999) 4th Ed

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Skill Enhancement Course (any four) (Credit: 02 each)- SEC1 to SEC4

PHYSICS WORKSHOP SKILL

30 Lectures

The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc. **(4 Lectures)**

Mechanical Skill: Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet. **(10 Lectures)**

Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.

(10 Lectures)

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment. **(6 Lectures)**

Reference Books:

- A text book in Electrical Technology - B L Theraja – S. Chand and Company.
- Performance and design of AC machines – M.G. Say, ELBS Edn.
- Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
- Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

COMPUTATIONAL PHYSICS
Theory: 30 Lectures

The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics and Science.

- *Highlights the use of computational methods to solve physical problems*
- *Use of computer language as a tool in solving physics/science problems*
- *Course will consist of hands on training on the Problem solving on Computers.*

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. **(4 Lectures)**

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems. **(5 Lectures)**

Control Statements: Types of Logic(Sequential, Selection, Repetition), Branching Statements (Logical **IF**, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1 **(6 Lectures)**

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. **Equation representation:** Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. **(6 Lectures)**

Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Hands on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.

12. Motion of particle in a central force field and plot the output for visualization.

(9 Lectures)

Reference Books:

- Introduction to Numerical Analysis, S.S.Sastry, 5th Edn.,2012, PHI Learning
- Computer Programming in Fortran 77". V. Rajaraman (Publisher:PHI).
- LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
- Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
- Computational Physics: An Introduction, R. C. Verma, etal. New Age International Publishers, New Delhi(1999)
- Elementary Numerical Analysis, K.E.Atkinson,3rd Edn.,2007,Wiley India Edition.

ELECTRICAL CIRCUITS AND NETWORK SKILLS

Theory: 30 Lectures

The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. **(3 Lectures)**

Electrical Circuits: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **(4 Lectures)**

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **(4 Lectures)**

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. **(2 Lectures)**

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor

(3 Lectures)

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources **(3 Lectures)**

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Relay protection device. **(3 Lectures)**

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, and solder. Preparation of extension board. **(5 Lectures)**

Network Theorems: (1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem. **(3 Lectures)**

Laboratory exercises:

AT LEAST 08 EXPERIMENTS FROM THE FOLLOWING

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem (IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify (1) Faraday's law and (2) Lenz's law.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter
11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

Reference Books:

- Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja
- Performance and design of AC machines - M G Say ELBS Edn.

RENEWABLE ENERGY AND ENERGY HARVESTING

Theory:30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean

Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. **(3 Lectures)**

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems. **(6 Lectures)**

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **(3 Lectures)**

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. **(3 Lectures)**

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. **(2 Lectures)**

Geothermal Energy: Geothermal Resources, Geothermal Technologies. **(2 Lectures)**

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. **(2 Lectures)**

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power **(4 Lectures)**

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications **(2 Lectures)**

Carbon captured technologies, cell, batteries, power consumption **(2 Lectures)**

Environmental issues and Renewable sources of energy, sustainability. **(1 Lecture)**

Demonstrations and Experiments

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Reference Books:

- Non-conventional energy sources, B.H. Khan, McGraw Hill
- Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
- Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.

- Renewable Energy, 3rd Edition,
- Solar Energy: Resource Assesment Handbook, P Jayakumar, 2009
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
- http://en.wikipedia.org/wiki/Renewable_energy

ENGINEERING DESIGN AND PROTOTYPING
(Credits: 02)
Theory: 30 Lectures

"How I See is How I Understand"
Drawings and pictorial representations are simple but effective tools in engineering crafts and one of the best ways to communicate ideas, learnings, and concepts. The purpose of this SEC is to empower the learners to think computationally and communicate pictorially.

Introduction: Fundamentals of Engineering design, design process and sketching: Scales and dimensioning, Designing to Standards (ISO Norm Elements/ISI), Engineering Curves: Parabola, hyperbola, ellipse and spiral. **(4 Lectures)**

Projections: Principles of projections, Orthographic projections: straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids. Intersection and Interpenetration of solids. Isometric and Oblique parallel projections of solids. **(10 Lectures)**

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD specific skills (graphical user interface, create, retrieve, edit, and use symbol libraries). Use of Inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D drawings. Annotating in Auto CAD with text and hatching, layers, templates and design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. Basic printing and editing tools, plot/print drawing to appropriate scale. **(10 Lectures)**

Computer Aided Design and Prototyping: 3D modeling with AutoCAD (surfaces and solids), 3D modeling with Sketchup, 3D designs, Assembly: Model Editing; Lattice and surface optimization; 2D and 3D packing algorithms, Additive Manufacturing Ready Model Creation (3D printing), Technical drafting and Documentation.

(6 Lectures)

References:

- Engineering Drawing, N.S. Parthasarathy and Vele Murali, 1st Edition, 2015, Oxford University Press
- Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International

- Engineering Drawing, Dhananjay A Jolhe, McGraw-Hill
- AutoCAD 2014 and AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
- Don S. Lemons, Drawing Physics, MIT Press, M A Boston, 2018, ISBN:9780262535199
- Norton, Robert L. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, M A Boston, McGraw-Hill, 2007.
- James A. Leach, AutoCAD 2017 Instructor, SDC publication, Mission, KS 2016. ISBN: 978163057029.

APPLIED OPTICS
THEORY: 30 Lectures

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

(i) Sources and Detectors (9 Periods)

Lasers, Spontaneous and stimulated emissions, Theory of laser action, Einstein's coefficients, Light amplification, Characterization of laser beam, He-Ne laser, Semiconductor lasers.

Experiments on Lasers:

a. Determination of the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
c. To find the polarization angle of laser light using polarizer and analyzer
d. Thermal expansion of quartz using laser

Experiments on Semiconductor Sources and Detectors:

a. V-I characteristics of LED
b. Study the characteristics of solid state laser
c. Study the characteristics of LDR
d. Photovoltaic Cell
e. Characteristics of IR sensor

(ii) Fourier Optics (6 Periods)

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

Experiments on Fourier Optics:

a. Fourier optic and image processing

1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system

b. Fourier Transform Spectroscopy

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

Experiment:

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

(iii) Holography (6 Periods)

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition

Experiments on Holography and interferometry:

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

(iv) Photonics: Fibre Optics (9 Periods)

Optical fibres and their properties, Principal of light propagation through a fibre, Thenumerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating

Experiments on Photonics: Fibre Optics

a. To measure the numerical aperture of an optical fibre
b. To study the variation of the bending loss in a multimode fibre
c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
d. To measure the near field intensity profile of a fibre and study its refractive index profile
e. To determine the power loss at a splice between two multimode fibre

Reference Books:

- LASERS: Fundamentals & applications, K.Thyagrajan & A.K.Ghatak, 2010, Tata McGraw Hill
- Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
- Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press
- Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
- Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.

WEATHER FORECASTING

Theory: 30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement **(9 Periods)**

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

(4 Periods)

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

(3 Periods)

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion **(6 Periods)**

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts. **(8 Periods)**

Demonstrations and Experiments:

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
   (a) To calculate the sunniest time of the year.
   (b) To study the variation of rainfall amount and intensity.
   (c) To observe the sunniest/driest day of the week.
   (d) To examine the maximum and minimum temperature throughout the year.
   (e) To evaluate the relative humidity of the day.
   (f) To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non aviation).
5. Simulation of weather system
6. Field visits to India Meteorological department and National center for medium range weather forecasting

Reference books:

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agro meteorology, S.R. Ghadekar, 2005,Agromet Publishers, Nagpur.

Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.----------

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