### SEMESTER I

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TOTAL CREDITS TO BE EARNED FOR THE AWARD THE DEGREE = 67

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### ELECTIVES FOR M.E HIGH VOLTAGE ENGINEERING

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1. ADVANCED MATRIX THEORY: 9

2. LINEAR PROGRAMMING 9

3. ONE DIMENSIONAL RANDOM VARIABLES 9

4. QUEUEING MODELS 9

5. COMPUTATIONAL METHODS IN ENGINEERING 9

L + T: 45 + 15 = 60

BOOKS FOR REFERENCE:
1. INTRODUCTION

2. SOLUTION OF FIELD EQUATIONS I
Limitations of the conventional design procedure, need for the field analysis based design, problem definition , solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

3. SOLUTION OF FIELD EQUATIONS II

4. FIELD COMPUTATION FOR BASIC CONFIGURATIONS
Computation of electric and magnetic field intensities– Capacitance and Inductance – Force, Torque, Energy for basic configurations.

5. DESIGN APPLICATIONS
Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

REFERENCES
5. User manuals of MAGNET, MAXWELL & ANSYS software.
1. GENERATION OF DIRECT VOLTAGES

2. GENERATION OF ALTERNATING VOLTAGES

3. GENERATION OF IMPULSE VOLTAGES

4. MEASUREMENT OF HIGH VOLTAGES
Peak voltage measurements by sphere gaps – Electrostatic voltmeter – generating voltmeters and field sensors – Chubb-Fortescue method – voltage dividers and impulse voltage measurements.

5. GENERATION AND MEASUREMENT OF IMPULSE CURRENTS

TOTAL : 45 PERIODS

REFERENCES

HV 9113 ELECTRICAL TRANSIENTS IN POWER SYSTEMS

1. TRAVELLING WAVES ON TRANSMISSION LINE
Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion – Multi-conductor system and Velocity wave.

2. COMPUTATION OF POWER SYSTEM TRANSIENTS

3. LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES
Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection - Voltage induced by fault – Very Fast Transient Overvoltage (VFTO)

4. BEHAVIOUR OF WINDING UNDER TRANSIENT CONDITION
Initial and Final voltage distribution - Winding oscillation - traveling wave solution - Behaviour of the transformer core under surge condition – Rotating machine – Surge in generator and motor

5. INSULATION CO-ORDINATION
Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level –overvoltage protective devices – lightning arresters, substation earthing.

TOTAL : 45 PERIODS

REFERENCES


6
1. GENERAL PROPERTIES OF INSULATING MATERIALS

2. BREAKDOWN MECHANISMS IN GASEOUS DIELECTRICS

3. BREAKDOWN MECHANISMS IN SOLID DIELECTRICS

4. BREAKDOWN MECHANISMS IN LIQUID DIELECTRICS
Liquids as insulators, conduction and breakdown in pure and commercial liquids, Cryogenic insulation.

5. APPLICATION OF INSULATING MATERIALS
Application of insulating materials in transformers, rotating machines, circuit breakers, cables, power capacitors and bushings.

REFERENCES

1. INTRODUCTION
Objectives of high voltage testing, classification of testing methods- self restoration and non-self restoration systems-standards and specifications, measurement techniques ,Diagnostic testing-online measurement.

2. STATISTICAL EVALUATION OF MEASURED RESULTS
Determination of probability values, Distribution function of a measured quantity, confidence limits of the mean values of disruptive discharges - ‘Up and Down’ method for determining the 50% disruptive discharge voltage, multi stress ageing, life data analysis

3. TESTING TECHNIQUES FOR ELECTRICAL EQUIPMENT
Testing of insulators, bushings, air break switches, isolators, circuit breakers, power transformers-voltage transformers-current transformers, surge diverters ,cable -testing methodology-recording of oscillograms - interpretation of test results

4. NON-DESTRUCTIVE INSULATION TEST TECHNIQUES
Dynamic properties of dielectrics-dielectric loss and capacitance measurement-partial discharge measurements-basic partial discharge(PD) circuit – PD currents- PD quantities -Digital PD instruments and measurements, acoustic emission technique and UHF Techniques for PD identification, Corona and RIV measurements on line hardware.

5. POLLUTION TESTS AND DESIGN OF HIGH VOLTAGE LAB
Artificial Pollution tests- salt-fog method, solid layer method, Dimensions of High voltage laboratory, equipment- fencing ,earthing and shielding, circuits for high voltage experiments.

TOTAL : 45 PERIODS

REFERENCES
1. INTRODUCTION
Basic arrangements of the insulation systems - factors affecting the performance of dielectric materials - Electric field distribution - utilization factor, field in homogeneous and multi-dielectric isotropic material

2. DESIGN OF INSULATORS, BUSHINGS AND CAPACITORS
Basic configurations, Classification based on insulating materials and application, design principles.

3. INSULATION DESIGN OF POWER TRANSFORMERS
Insulation schemes in transformer, design of transformer windings, surge phenomena in transformer windings - effect of series and shunt capacitance and stress control techniques.

4. DESIGN OF INSTRUMENT TRANSFORMERS AND CABLE JOINTS
Classification based on insulating materials and design of potential and current transformers, Types of cable joints and terminations - capacitive grading - non-linear resistive grading.

5. SURGE ARRESTER
Types of surge arresters - gapped and gapless - electrical characteristics - housing materials - pollution performance - modeling of arrester - insulation co-ordination.

REFERENCES
1. INTRODUCTION
Insulation of switchgear - coordination between inner and external insulation, Insulation clearances in air, oil, SF₆ and vacuum, bushing insulation, solid insulating materials – dielectric and mechanical strength consideration.

2. CIRCUIT INTERRUPTION

3. SHORTCIRCUIT CALCULATIONS AND RATING OF CIRCUITBREAKERS
Types of faults in power systems-short circuit current and short circuit MVA calculations for different types of faults-rating of circuit breakers – symmetrical and asymmetrical ratings.

4. TYPES OF CIRCUIT BREAKERS
Classification of circuit breakers-design, construction and operating principles of bulk oil, minimum oil, air blast, SF₆ and vacuum circuit breakers – Comparison of different types of circuit breakers.

5. TESTING OF CIRCUIT BREAKERS
Type tests and routine tests – short circuit testing-synthetic testing of circuit breakers-recent advancements in high voltage circuit breakers.

REFERENCES
1. INTRODUCTION 9
Standard transmission voltages – different configurations of EHV and UHV lines – average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance.

2. CALCULATION OF LINE PARAMETERS 9
Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – resistance and inductance of ground return, numerical example involving a typical 400/220kV line using line constant program.

3. VOLTAGE GRADIENTS OF CONDUCTORS 9
Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers.

4. CORONA EFFECTS 9

5. ELECTROSTATIC FIELD OF EHV LINES 9
Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference.

TOTAL: 45 PERIODS

REFERENCE

HV 9125 HIGH VOLTAGE LABORATORY

1. High voltage AC measurement.
2. High voltage DC measurement.
3. High Impulse voltage measurement.
4. Study of break down phenomena in air, oil and solid dielectrics under uniform and non-uniform electrode configurations.
5. Capacitance and loss tangent measurement.
6. Partial discharge measurement.
8. Measurement of resonant frequencies and internal voltage distribution in transformer windings.
9. Electromagnetic field measurement using field meter.

P = 45   Total= 45

HV 9131 PROJECT WORK (PHASE I)  

0  0  12  6

HV 9141 PROJECT WORK (PHASE – II)  

0  0  24  12
1. STATE VARIABLE REPRESENTATION
Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-Nonuniqueness of state model-State Diagrams-Physical System and State Assignment.

2. SOLUTION OF STATE EQUATION

3. CONTROLLABILITY AND OBSERVABILITY
Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

4. STABILITY

5. MODAL CONTROL
Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL : 45 PERIODS

REFERENCES:
1. **PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION**  
   General expression of stored magnetic energy, co-energy and force/torque – example using single and doubly excited system – Calculation of air gap mmf and per phase machine inductance using physical machine data.

2. **REFERENCE FRAME THEORY**  

3. **DC MACHINES**  
   Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

4. **INDUCTION MACHINES**  

5. **SYNCHRONOUS MACHINES**  

**TOTAL : 45 PERIODS**

**TEXT BOOKS**

**REFERENCES**
AIM
To expose the students to the fundamentals of digital logic based system design.

OBJECTIVES
To impart knowledge on
i. Basics on Synchronous & Async digital switching design.
ii. Design & realisation of error free functional blocks for digital systems

1. SEQUENTIAL CIRCUIT DESIGN

2. ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN

3. FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS

4. SYNCHRONOUS DESIGN USING PROGRAMMABLE DEVICES
   Programming Techniques -Re-Programmable Devices Architecture- Function blocks, I/O blocks, Interconnects, Realize combinational, Arithmetic, Sequential Circuit with Programmable Array Logic; Architecture and application of Field Programmable Logic Sequence.

5. NEW GENERATION PROGRAMMABLE LOGIC DEVICES

REFERENCES:
1. **INTRODUCTION**

Reactive power control in electrical power transmission lines - Uncompensated transmission line - series compensation – Basic concepts of static Var Compensator (SVC) – Thyristor Switched Series capacitor (TCSC) – Unified power flow controller (UPFC).

2. **STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS**


3. **THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS**


4. **VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS**


5. **CO-ORDINATION OF FACTS CONTROLLERS**


**TOTAL : 45 PERIODS**

**REFERENCES**

1. INTRODUCTION
Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

2. NON-LINEAR LOADS
Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

3. MEASUREMENT AND ANALYSIS METHODS

4. ANALYSIS AND CONVENTIONAL MITIGATION METHODS
Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

5. POWER QUALITY IMPROVEMENT

TOTAL : 45 PERIODS

TEXT BOOKS
3. Power Quality - R.C. Duggan
5. Power electronic converter harmonics –Derek A. Paice
1. PIC 16C7X MICROCONTROLLER
Architecture memory organization – Addressing modes – Instruction set – Programming techniques – simple programs

2. PERIPHERALS OF PIC 16C7X
Timers – interrupts – I/O ports – I²C bus for peripheral chip access – A/D converter – UART

3. MOTOR CONTROL SIGNAL PROCESSORS
Introduction- System configuration registers - Memory Addressing modes - Instruction set – Programming techniques – simple programs

4. PERIPHERALS OF SIGNAL PROCESSORS
General purpose Input/Output (GPIO) Functionality- Interrupts - A/D converter-Event Managers (EVA, EVB)- PWM signal generation

5. APPLICATIONS OF PIC AND SIGNAL PROCESSORS
Voltage regulation of DC-DC converters- Stepper motor and DC motor control- Clarke’s and parks transformation-Space vector PWM- Control of Induction Motors and PMSM.

TOTAL : 45 PERIODS

TEXT BOOKS:
1. STEPPING MOTOR
Constructional features – Principle of operation – Modes of excitation – Torque production in variable reluctance stepping motor - Dynamic characteristics – Drive systems and circuit for open loop control – Closed loop control of stepping motor.

2. SWITCHED RELUCTANCE MOTORS
Constructional features – principle of operation – Torque equation – Power controllers – Characteristics and control microprocessor based controller.

3. SYNCHRONOUS RELUCTANCE MOTORS

4. PERMANENT MAGNET SYNCHRONOUS MOTORS

5. PERMANENT MAGNET BRUSHLESS DC MOTORS
Commutation in DC motors, Difference between mechanical and electronic commutators- Hall sensors, Optical sensors - Multiphase Brushless motor –Square wave permanent magnet brushless motor drives –Torque and emf equation-Torque speed characteristics-Controllers –Microprocessors based controller

TOTAL : 45 PERIODS

REFERENCES


ET 9159 ADVANCED DIGITAL SIGNAL PROCESSING

1. INTRODUCTION
Mathematical description of change of sampling rate – Interpolation and Decimation, Filter implementation for sampling rate conversion – direct form FIR structures, DTFT, FFT, Wavelet transform and filter bank implementation of wavelet expansion of signals

2. ESTIMATION AND PREDICTION TECHNIQUES

3. DIGITAL SIGNAL PROCESSOR
Basic Architecture – Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA.

4. APPLICATION OF DSP
Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control.

5. VLSI IMPLEMENTATION
Basics on DSP system architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realisation of MAC & Filter structure.

TOTAL : 45 PERIODS

REFERENCES:
1. DATA ACQUISITION AND INSTRUMENT INTERFACE
   Programming and simulation of Building block of instrument Automation system –
   Signal analysis, I/O port configuration with instrument bus protocols - ADC, DAC,
   DIO, counters & timers, PC hardware structure, timing, interrupts, DMA, software
   and hardware installation, current loop, RS 232/RS485, GPIB, USB protocols,

2. VIRTUAL INSTRUMENTATION PROGRAMMING TECHNIQUES
   Block diagram and architecture of a virtual instrument, Graphical programming in
   data flow, comparison with conventional programming, Vis and sub-Vis, loops
   and charts, arrays, clusters and graphs, case and sequence structures, formula
   nodes, local and global variables, string and file I/O.

3. DESIGN TEST & ANALYSIS
   Spectral estimation using Fourier Transform, power spectrum, correlation
   methods, Stability analysis, Fault analysis –Sampling, Data Parity and error
   coding checks, Synchronization testing – Watch dog timer, DMA method – Real-
   time Clocking, Noise- Gaussian, White analysis

4. PC BASED INSTRUMENTATION
   Introduction – Evolution of signal standard – HART Communication protocol –
   Communication modes – HART networks – control system interface – HART
   commands – HART field controller implementation – HART and the OSI model

5. SIMULATION OF PHYSICAL SYSTEMS
   Simulation of linear & Non-linear models of systems, Hardware in loop simulation
   of physical systems using special softwares.

L=30, P=10, Total=45

REFERENCES:
   2002.
4. MAPLE V programming guide
5. MATLAB/SIMULINK user manual
6. MATHCAD/VIS SIM user manual.
7. LABVIEW simulation user manual
1. MEASUREMENT AND DIAGNOSTIC TECHNOLOGIES


2. APPLICATION OF HIGH VOLTAGE ENGINEERING IN INDUSTRY


3. SAFETY AND ELECTROSTATIC HAZARDS


4. PULSED ELECTRIC FIELDS

Introduction-definitions, descriptions and applications-mechanisms of microbial inactivations-electrical breakdown-electroporation-inactivation models -Critical factors-analysis of process, product and microbial factors-pulse generators and treatment chamber design-Research needs.

5. APPLICATION OF PEF TECHNOLOGY IN FOOD PRESERVATION

Processing of juices, milk, egg, meat and fish products- Processing of water and waste. Industrial feasibility, cost and efficiency analysis.

TOTAL : 45 PERIODS

REFERENCES

1. INTRODUCTION

2. POLLUTION TESTING

3. POLLUTION PERFORMANCE OF INSULATORS
Ceramic and non-ceramic insulators – design of shed profiles – rib factor effect in AC and DC insulators – modeling.

4. POLLUTION PERFORMANCE OF SURGE DIVERTERS
External insulation – effect of pollution on the protective characteristics of gap and gapless arresters – modeling of surge diverters under polluted conditions.

5. POLLUTION PERFORMANCE OF INDOOR EQUIPMENT
Condensation and contamination of indoor switch gear – performance of organic insulator under polluted conditions – accelerated testing techniques.

REFERENCES
INTRODUCTION
Sources of EMI, Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation- typical noise path- use of network theory- methods of eliminating interferences.

METHOD OF HARDENING

BALANCING, FILTERING AND SHIELDING

DIGITAL CIRCUIT NOISE AND LAYOUT

ELECTROSTATIC DISCHARGE, STANDARDS AND LABORATORY TECHNIQUES

REFERENCES
PS 9154 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION

1. DC POWER TRANSMISSION TECHNOLOGY
   - Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

2. ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL
   - Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters.
   - General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.

3. MULTITERMINAL DC SYSTEMS
   - Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

4. POWER FLOW ANALYSIS IN AC/DC SYSTEMS
   - Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow - Case studies.

5. SIMULATION OF HVDC SYSTEMS

TOTAL : 45 PERIODS

REFERENCES
1. INTRODUCTION

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine

2. WIND TURBINES

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.

3. FIXED SPEED SYSTEMS

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model for Steady state and Transient stability analysis.

4. VARIABLE SPEED SYSTEMS

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

5. GRID CONNECTED SYSTEMS

Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries

TOTAL : 45 PERIODS

REFERENCES

CO9151 SOFT COMPUTING TECHNIQUES

1. INTRODUCTION

2. ARTIFICIAL NEURAL NETWORKS
Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

3. FUZZY LOGIC SYSTEM
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.

4. GENETIC ALGORITHM
Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and anD-colony search techniques for solving optimization problems.

5. APPLICATIONS

REFERENCES

TOTAL : 45 PERIODS
1. MODELS FOR IDENTIFICATION


2. NON-PARAMETRIC AND PARAMETRIC IDENTIFICATION


3. NON-LINEAR IDENTIFICATION AND MODEL VALIDATION


4. ADAPTIVE CONTROL AND ADAPTATION TECHNIQUES


5. CASE STUDIES

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

TOTAL: 45 PERIODS

REFERENCES:

3. Astrom and Wittenmark,” Adaptive Control “, PHI
1. INTRODUCTION


2. LQ CONTROL PROBLEMS AND DYNAMIC PROGRAMMING


3. NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL

Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods

4. FILTERING AND ESTIMATION


5. KALMAN FILTER AND PROPERTIES


REFERENCES:

1. MEMS: MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS
Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

2. ELECTROSTATIC SENSORS AND ACTUATION
Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

3. THERMAL SENSING AND ACTUATION
Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

4. PIEZOELECTRIC SENSING AND ACTUATION
Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

5. CASE STUDIES
Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.

TOTAL : 45 PERIODS

REFERENCES