RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA, BHOPAL

New Scheme Based On AICTE Flexible Curricula

Mechatronics Engineering, IV-Semester (w. e .f. Jan-2026)

BT 401	**Mathematics-III**	**3L-1T-0P**	**4 Credits**

Course Objectives:

The objective of this course is to fulfill the needs of engineers to understand applications of Numerical Analysis, Transform Calculus and Statistical techniques in order to acquire mathematical knowledge and to solving wide range of practical problems appearing in different sections of science and engineering.

More precisely, the objectives are:

1. To introduce effective mathematical tools for the Numerical Solutions algebraic and¬ transcendental equations.

2.To enable young technocrats to acquire mathematical knowledge to understand Laplace¬ transformation, Inverse Laplace transformation and Fourier Transform which are used in various branches of engineering.

3. To acquaint the student with mathematical tools available in Statistics needed in various¬ field of science and engineering.

Module 1: Numerical Methods – 1: (8 hours): Solution of polynomial and transcendental equations – Bisection method, Newton-Raphson method and Regula-Falsi method. Finite differences, Relation between operators, Interpolation using Newton's forward and backward difference formulae. Interpolation with unequal intervals: Newton's divided difference and Lagrange's formulae.

Module 2: Numerical Methods – 2: (6 hours): Numerical Differentiation, Numerical integration: Trapezoidal rule and Simpson's 1/3rd and 3/8 rules. Solution of Simultaneous Linear Algebraic Equations by Gauss's Elimination, Gauss's Jordan, Crout's methods, Jacobi's, GaussSeidal, and Relaxation method.,

Module 3: Numerical Methods – 3: (10 hours): Ordinary differential equations: Taylor's series, Euler and modified Euler's methods. RungeKutta method of fourth order for solving first and second order equations. Milne's and Adam's predicator-corrector methods. Partial differential equations: Finite difference solution two dimensional Laplace equation and Poission equation, Implicit and explicit methods for one dimensional heat equation (Bender-Schmidt and Crank-Nicholson methods), Finite difference explicit method for wave equation.

Module 4: Transform Calculus: (8 hours): Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs by Laplace Transform method, Fourier transforms.

Module 5: Concept of Probability: (8 hours): Probability Mass function, Probability Density Function, Discrete Distribution: Binomial, Poisson's, Continuous Distribution: Normal Distribution, Exponential Distribution.

Textbooks/References:

1. P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical Methods, S. Chand & Company, 2nd Edition, Reprint 2012.

2. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4th Edition, 2005.

3. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2010.

5. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.

6. Veerarajan T., Engineering Mathematics, Tata McGraw-Hill, New Delhi, 2008.

7. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).

8. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

9. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968. Statistics.

EVALUATION

Evaluation will be continuous an integral part of the class as well through external assessment.

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MT 402: Machine Design

Course Objectives:

To study the basic design principles and apply the principles to the design of various elements encountered in Mechanical machines and structures.

Course Outcomes:

1.To determine the strength of the components

2.To determine the failure conditions and apply them to real life Problems

3.To design simple joints, fasteners, levers and springs.

4. To design belt,rope and chain drives

5. To design different types of gears

Unit 1: Mechanical Engineering design - Design considerations, Design Procedure Material selection Modes of failure - Theories of failure , causes of stress concentration; stress concentration in tension, bending and torsion; reduction of stress concentration, theoretical stress concentration factor, notch sensitivity, fatigue stress concentration factor, cyclic loading, endurance limit, S-N Curve, loading factor, size factor, surface factor. Design consideration for fatigue, Goodman and modified Goodman's diagram, Soderberg equation, Gerber parabola, design for finite life, cumulative fatigue damage

Unit 2 Design of Fasteners : Design of cotter and knuckle joints.. Fasteners and keys , Design of welded joints , Fillet and butt welds , Design of riveted joints. Design of bolted joints . Power screws .

Unit 3: Design of bearings and Springs

Design of Bearings: Reynold's equation, stable and unstable operation, heat dissipation and thermal equilibrium, boundary lubrication, dimensionless numbers, Design of journal bearings, Rolling-element Bearings: Types of rolling contact bearing, bearing friction and

power loss, bearing life; Radial, thrust & axial loads; Static & dynamic load capacities; Selection of ball and roller bearings; lubrication and sealing.

Design of Springs : Design of helical compression & tension spring , design of leaf spring & torsion springs , fatigue loading of springs ,surge in springs ,spiral springs .

Unit 4: Design of Belt, Rope and Chain Drives: Methods of power transmission, selection and design of flat belt and pulley; Selection of V-belts and sheave design; Design of chain drives, roller chain and its selection; Rope drives, design of rope drives, hoist ropes.

Unit 5 : Spur and Helical Gears: Force analysis of gear tooth, modes of failure, beam strength, Lewis equation, form factor, formative gear and virtual number of teeth; Gear materials; Surface strength and wear of teeth; strength against wear; Design of straight tooth spur and Helical Gears.

Bevel Gears: Application of bevel, formative gear and virtual number of teeth; Force analysis; Lewis equation for bevel gears; Strength against wear; Design of bevel gear.

EVALUATION

Evaluation will be continuous an integral part of the class as well through external assessment.

References :

1 Robert C Juvinal, Kurt M Marshek Machine Component design Wiley Student edition

2 C S Sharma & Kamlesh Purohit , Design of machine elements PHI

Sharma & Agarwal Machine design .

4 Pandya & Shah , Charottar .

5 J E Shingley Machine design Mc Graw Hills

6 Gope P C , Machine Design , PHI Learning . 2015

7 P Kannaiah , Machine Design , SCITECH .

8 Nortan RL , Machine Design , Pearson , Fifth Edition

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MT403 : Systems Engineering

This course in systems engineering examines the principles and process of creating effective systems to meet application demands.

The course is organized as a progression through the systems engineering processes of analysis, design, implementation, and deployment with consideration of verification and validation throughout.

COURSE OUTCOMES:

After successful completion of the course, students would be able to

* Plan and manage the systems engineering process

* Examine systems from many perspectives (such as software, hardware, product, etc.)

* Distinguish critical functions, diagnose problems, and apply descoping strategies and judge the complexity of production and deployment issues.

* Know about the complexity in modern systems such as in missiles, rocket engines, modern automobiles etc.

* Solve real complex problems Syllabus:

Unit 1: Overview of Systems Engineering:

Introduction, Origin, Examples of Systems requiring systems engineering,Systems Engineer Career Development Model, Perspectives of Systems Engineering, Systems Domains, Systems Engineering Fields, System Engineering Approaches

Unit 2: Structure of Complex Systems:

System Building Blocks and Interfaces, Hierarchy of Complex Systems, System Building Blocks, The System Environment, Interfaces and Interactions, Complexity in Modern Systems.

Unit 3 Concept Development and Exploration:

Originating a New System, Operational Analysis, Functional Analysis, Feasibility, System Operational Requirements, Implementation of Concept Exploration.Exploration in system life cycle, Concept definition phase, Activities involved in concept definition phase.

Unit 4: Engineering Development:

Reducing Program Risks, Requirements Analysis, Functional Analysis and Design, Prototype Development as a Risk Mitigation Technique, Development Testing, Risk Reduction. Place of engineering design phase in system life cycle, Various activities involved in engineering design phase.

Unit 5: Integration and Evaluation:

Integrating, Testing, And Evaluating The Total System, Test Planning And Preparation, System Integration, Developmental System Testing, Operational Test And Evaluation, Engineering For Production, Transition From Development To Production, Production Operations.operation and support phase.

Text Books:

1. Dwivedi Krishna K, Pandey M., Fundamentals of Systems Engineering , Wiley Precise Text book Series, Wiley India. ISBN: 978-265-6654-9

2.Alexander Kossiakoff, William N Sweet, "System Engineering Principles and Practice, Wiley India

3..Blanchard Fabrycky, Systems engineering and analysis, Pearson

4. Dennis M. Buede, William D.Miller, "The Engineering Design of Systems: Models & Methods" Wiley India

5.JeffreyL Whitten, Lonnie D Bentley, "System Analysis and Design Methods"

6.Richard Stevens, Peter Brook," System Engineering – Coping with complexity, Prentice Hall of India.

7.Eisner, H. Essentials of Projects and Systems Engineering Management, 2nd edition. John Wiley & Sons, New Jersey, USA.

8. Buede, D. M.. The Engineering Design of Systems, Models and Methods. John Wiley & Sons, New Jersey, USA.

Evaluation: Evaluation will be continuous and integral part of the class as well as through external assessment

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MT-404 : Digital Systems

Unit 1: Review of number systems and number base conversions.

Binary codes, Boolean algebra, Boolean functions, Logic gates. Simplification of Boolean functions, Karnaugh map methods, SOP-POS simplification, NAND-NOR implementation.

Unit 2: Combinational Logic:

Half adder, Half subtractor, Full adder, Full subtractor, look- ahead carry generator,BCD adder, Series and parallel addition, Multiplexer – demultiplexer, encoder- decoder, arithmetic circuits, ALU

Unit 3 : Sequential logic:

Flip flops, D,T, S-R, J-K Master- Slave, racing condition, Edge & Level triggered circuits, Shift registers, Asynchronous and synchronous counters, their types and state diagrams. Semiconductor memories, Introduction to digital ICs 2716, 2732 etc. & their address decoding. Modern trends in semiconductor memories such as DRAM, FLASH RAM etc. Designing with ROM and PLA.

Unit 4 : Introduction to A/D & D/A convertors & their types:
Sample and hold circuits, Voltage to Frequency & Frequency to Voltage conversion. Multivibrators :Bistable, Monostable, Astable, Schmitt trigger, IC 555 & Its applications. TTL, PMOS, CMOS and NMOS logic. Interfacing between TTL to MOS.

Unit 5 : Introduction to Digital Communication:

Nyquist sampling theorem, time division multiplexing, PCM, quantization error, introduction to BPSK & BFSK modulation schemes. Shannon's theorem for channel capacity.

References:

1. Morris Mano, Digital Circuits & Logic Design, PHI

2. Gothman, Digital Electronics, PHI

3. Tocci, Digital Electronics, PHI

4. Mavino& Leach, Digital Principles & Applications, PHI

5. Taub and schilling, Digital Integrated electronics.

6. Simon Haykin, Introductionto Analog& Digital Communication, Wiley.

7. Lathi B.P., Modern analog& digital communication , Oxford University.

Suggested List of Experiments:

1. To study and verify the truth tables of various Logic gates

2. To verify the properties of NAND and NOR gates as Universal Building Blocks.

3. Simplification and implementation of a Boolean function

4. Implementation of basic Boolean arithmetic logic circuits such as Half-adder, Half-subtractor, Full adder and Full subtractor

5. Conversion from Binary to Gray and Gray to Binary code

6. To construct a binary multiplier using combinational logic and to verify with the truth table

7. To verify 2-bit Magnitude comparator for all possible conditions

8. Generation of various logical functions using 8-to-1 multiplexer

9. Construction of a 4-bit ripple counter and study of its operation

10. Operation of IC-555 Timer as Monostable, Astable and Bistablemultivibrators

11. To characterize binary ladder type digital to analog (D/A) and analog to digital (A/D) convertor

12. Comparison of various Logic families

13. Design and implementation of various types of flip-flops using JK flip-flop

14. To study natural sampling of continuous time waveforms using different sampling rates

15. To study Pulse-Code modulation with Time-division multiplexing (PCM-TDM)

16. To study generation and detection of BPSK and QPSK waveforms

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MT 405: Electronic Devices

Syllabus:

Unit-1 Semiconductor Material Properties:

Elemental & compound semiconductor materials , Bonding forces and Energy bands in intrinsic and extrinsic silicon, Charge carrier in semiconductors , carrier concentration, Junction properties, Equilibrium condition, biased junction, Steady state condition, breakdown mechanism (Rectifying Diodes, Zener Diodes), Metal Semiconductor Junction. Special diodes: Tunnel diodes, Varactor diodes, Schottky diode, Photo diodes, Photodetector, LED, solar cell.

Unit-2 Diode circuits:

Ideal and Practical diode, Clipper, Clamper. Power Supply: Rectifiers-Half wave, Full wave, Bridge rectifier, filter circuits, Voltage regulation using shunt & series regulator circuits, Voltage regulation using IC.

Unit-3 Fundamentals of BJT:

Construction, basic operation, current components and equations,CB, CE and CC configuration, input and output characteristics, Early effect, Region of operations: active, cut-off and saturation region. BJT as an amplifier. Ebers-Moll model, Power dissipation in transistor (Pd, max rating), Photo transistor. Transistor biasing circuits and analysis: Introduction, various biasing methods: Fixed bias,Self bias, Voltage Divider bias, Collector to base bias, Load-line analysis: DC and AC analysis, Operating Point and Bias Stabilization and Thermal Runaway. Transistor as a switch.

Unit-4 Small Signal analysis:

Small signal Amplifier,Amplifier Bandwidth, Hybrid model, analysis of transistor amplifier using h-parameter, Multistage Amplifier: Cascading amplifier, Boot-strapping Technique, Darlington amplifier and cas-code amplifier, Coupling methods in multistage amplifier, Low and high frequency response, Hybrid πmodel, Current Mirror circuits. Large Signal analysis and Power Amplifiers: Class A,Class B,Class AB, Class C, Class D, Transformer coupled and Push-Pull amplifier.

Unit-5 FET construction-

JFET: Construction, n-channel and p-channel, transfer and drain characteristics, parameters, Equivalent model and voltage gain, analysis of FET in CG, CS and CD configuration. Enhancement and Depletion MOSFET drain and transfer Characteristics. Unijunction Transistor (UJT) and Thyristors: UJT: Principle of operation, characteristics, UJT relaxation oscillator.

Text/Reference Books:

1. Millman & Halkias, "Electronic Devices And Circuits", TMH.

2. Salivahanan, Kumar & Vallavaraj, "Electronic Devices And Circuits", TMH.

3. Boylestad & Neshelsky, "Electronic Devices & Circuits", PHI.

4. Schilling & Belove, "Electronic Circuits , Discrete & Integrated", TMH.

5. Chattopadhyay & Rakhshit, "Electronic Fundamentals & Applications", New Age

6. Adel S. Sedra & Kenneth C. Smith, "Microelectronic Circuits", OUP.

7. R. A. Gayakwad, "Op-Amps And Linear Integrated Circuits", PHI

8. Theodore F. Bogart, Jeffrey S. Beasley, "Guillermo Rico Electronic Devices & Circuits".

9. Allen Mottershead, "Electronic Devices & Circuits".

Suggested List of Experiments

1. Diode Characteristic

a) PN junction diode Characteristics and Static & Dynamic resistance measurement from graph.

b) To plot Zener diode Characteristics curve.

2. Clipper Clamper

a) To plot the Characteristics curve of various clamper circuits.

b) To plot the Characteristics curve of various clamper circuits.

3. Half wave, full wave & bridge rectifier

a) To measure Vrms, Vdc for half wave, full wave & bridge rectifier.

b) To measure ripple factor, ratio of rectification for full wave & half wave rectifier.

4. Voltage regulation using zener diode shunt regulator and transistor series voltage regulator in the following cases a) Varying input b) Varying load

5. Characteristic of BJT

a) To plot the input & output Characteristics curve in CB & CE configuration

b) To find α & β and Q point from the above curve.

c) To plot the Characteristics curve of various clipper circuits.

6. h- Parameter To measure h- parameter (Av, Ai, Ro & Ri) in CE Amplifier

7. Multi Stage Amplifier

a) To plot the Characteristics curve for Direct Coupled Amplifier.

b) To plot the Characteristics curve for RC Coupled Amplifier.

c) To plot the Characteristics curve for transformer Coupled Amplifier.

8. FET Characteristic

a) To plot the Characteristics curve for n channel – JFET in CS configuration.

b) To find out pinch off voltage from the above characteristics curve

9 UJT Characteristic

a) To plot the Characteristics curve for UJT.

b) To determine intrinsic stand off ratio.

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MT-406: FEM/CFD Lab

Suggested List of Experiments (Please Expand it)

1. To study fundamentals of Computational Fluid Dynamics (CFD)
2. To perform CFD analysis of lid driven cavity in Open-Foam
3. To perform CFD analysis of square tube in Open-Foam
4. To perform CFD analysis of a 2D-plate in Open-Foam
5. To perform CFD analysis of bifurcated blood vessel in FEM
6. To study fundamentals of Finite element method and FEA
7. To perform FEM analysis of deep drawing process in FEM
8. To study fundamentals of Sci-Lab
9. To perform matrix operations in Sci-lab
10. To plot 2D & 3D graphs in Sci-lab

References:

1. Versteeg H; An introduction to Computational Fluid Dynamics (The Finite Volume Method);Pearson
2. Jiyuan Tu; Computational Fluid Dynamics: A Practical Approach; ButterworthHeinemann.
3. Gokhale NS; Practical Finite Element Analysis; Finite to Infinite
4. Seshu P; Finite element analysis; PHI.
5. Reddy JN; Introduction to the Finite Element Method;McGraw Hill Inc.
6. Das VV; Programming in Scilab 4.1; New Age International Publishers.
7. Verma A K; Scilab : A Beginner's Approach; Cengage publishers.

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