Sem 3 ME

Syllabus

Course Name: Linear Algebra and Differential Equations [3:0:0=3]

Course Content:

REF and RREF of a matrix, Rank of a matrix, Linear equations, and their solutions using Gaussian elimination method and Gauss-Jordan method, Eigenvalues and eigenvectors, its applications in Markov chain, dynamical systems and system of differential equations, diagonalization of matrices, Vector spaces, subspaces, linear dependence and independence of vectors, linear combination of vectors, spanning set of vectors, basis and dimension of a vector space, Linear transformation and its matrix representation, Kernel and range of Linear transformation.

Solution of Exact, linear and Bernoulli's differential equations, applications of differential equations of first order & first degree to simple electric circuits, Newton's law of cooling and orthogonal trajectories, Understanding the reduction of orders, Solution of higher order linear differential equations with constant coefficients, Method of undetermined coefficients, Variation of Parameters, Solution of Cauchy's and Legendre's equations, Modelling and solving linear differential equations of 2^{nd} and higher orders in engineering, Solution of system of linear Equations.

Course Outcomes:

CO1: Understand various concepts of linear systems, vector spaces, eigenvalues and eigenvectors, linear transformation, different types of ordinary differential equations that arise in different fields of engineering problems.

CO2: Apply the concepts of eigenvalue, eigenvectors, linear transformations in graphics and other engineering domains, apply suitable method to solve different types of ODEs arising in engineering and real-world applications.

CO3: Analyse the long-term behaviour of Markov chains and discrete/continuous dynamical systems, analyse the efficiency of different solution methods available to solve higher order ODEs.

CO4: Model real world problems and finding their solutions mathematically as well as with the help of technology and writing a report to summarize the findings.

Textbook:

1. D. Poole, *Linear Algebra: A Modern Introduction*, 4^{th} Edition, ISBN-13: 978-1-285-46324-7, Cengage Learning, 2015.
2. Zill D. G., *A First Course in Differential Equations with Modelling Applications*, 11^{th} Edition. ISBN-13: 978-0-495-10824-5, Brooks/Cole, Cengage Learning, 2010.

Reference Book:

1. David C. Lay, *Linear Algebra and Its Applications*, ISBN: 978-81-775-8333-5, 3^{rd} Edition, Pearson, 2014.

2. Seymour Lipschutz & Marc Lipson, *Schaum's Outline of Linear Algebra*, ISBN: 978-0071794565, 5th Edition, McGraw-Hill, 2014.

Course Name: Introduction to Robotics and IOT **[2:1:2=4]**

Theory:

- Rigid-Body Kinematics (forward and Inverse Kinematics)
- Newton-Euler Dynamics of Robots, Lagrangian Dynamics and Kane's Method in Robotics.
- Dynamics of Systems of Interacting Rigid Bodies and D-H Convention
- Trajectory Planning for Flexible Robots.
- Coordinated Motion Control of robots by Linear Feedback, Force/Impedance & Coordinated Motion.
- learn about IoT systems, its design, development, simulation, and deployments using any operating system like Linux/windows/any other using development kit like buildroot, Ubuntu, AWS CloudFormation, Packer, Pulumi, AWS Cloud etc using source emulator like QEMU, VirtualBox, KVM, Xen, Docker, libvirt, or any other.

Lab:

- Robot Simulation.
- Develop robot programs for applications like pick and place, welding, painting, loading-unloading, etc.
- Study components of IoT devices
- Experiment with communication protocols for IoT applications.
- Experiment with different Networks, Links & Loading of IoT devices.
- Analyse System Programming and OS Dependencies.
- Program IoT devices with C/ Python/ Ruby/etc.
- Integration of IoT with Cloud Computing Services for IoT applications.
- Design, develop, simulate, and deploy an IOT solution for 3 or more different applications with two or more different type of sensors of each application.

Course Outcomes:

CO1: Apply basic knowledge and understanding of science, maths, computer, and engineering to mechanize a manual or semi-automatic process or system using technology like internet of things.

CO2: Analyse the simulation and working of robots.

CO3: Design, simulate and deploy robotics/IoT solutions for different applications.

Textbook:

1. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, *Robot Dynamics and Control*, Wiley and Sons, Ltd.
2. Adrian McEwen, Hakim Cassimally, *Designing the Internet of Things*. John Wiley and Sons, Ltd. 2014. ISBN 978-1-118-43062-0.
3. David Warren, *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things*. Cisco Press; 1st edition (20 June 2017). ISBN-10 : 1587144565.

Reference Book:

1. Thomas R. Kurfess, *Robotics and Automation Handbook*. Edited CRC press.

2. Robert J Schilling, *Fundamentals of Robotics analysis and control*.
3. John E. Hopcroft, Jeffery Ullman, *Introduction to Automata theory, Languages & computation*. Pearson.
4. Kaushik Kumar, B. Sridhar Babu *Industrial Automation and Robotics Techniques and Applications*.
5. Maciej Kranz, *Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry*. Wiley (1st ed. 30 December 2016).
6. Klaus Schwab, *The Fourth Industrial Revolution*. Portfolio Penguin (22 February 2017). ISBN-13: 978-0241300756.
7. Olivier Hersent, David Boswarthick, and Omar Elloumi, *The Internet of Things: Key Applications and Protocols*. John Wiley & Sons Ltd. 2012. ISBN: 9781119994350.
8. Claire Rowland, Elizabeth Goodman, Martin Charlier, and Ann Light, *Designing Connected Products: UX for the Consumer Internet of Things*. O'Reilly Media; 1st edition (18 May 2015).
9. Min Chen , Yiming Miao & Iztok Humar, *OPNET IoT Simulation*. Springer Verlag, Singapore; 1st ed. 2019 edition (8 October 2019). ISBN-10 : 9813291699.
10. Brian Russell and Drew Van Duren, *Practical Internet of Things Security*. Packt Publishing Limited (29 June 2016). ISBN-10: 9781785889639.
11. Peter Waher, Pradeeka Seneviratne, Brian Russell & Drew Van Duren, *IoT: Building Arduino-Based Projects.* Packt Publishing Limited (31 August 2016). ISBN-10: 1787120635.

Course Name: Data Analytics using Python **[2:0:2=3]**

Course Content:

Introduction to Python -Google Colab and Jupyter Notebook, Data Structure, Pandas (reading, writing files, loading data, etc), NumPy, etc.**.** Matplotlib (area plot, scatter plot, line plot, histogram, bar charts, box plot, heat map, faceting, pair plot), seaborn. What is data science, Various types, and levels of data, Structured vs. Unstructured data, quantitative vs. qualitative data, Data science life cycle, etc. Data collection and preparation, Missing value handling, Data scrubbing, Data transformation, Exploratory Data Analytics, Population and sample, Moments and generating functions, Measure of Variability, Hypothesis Testing, bias, and variance. Supervised classification such as KNN and Unsupervised classification such as K-Mean Clustering, Model Definition, and Training, Model Evaluation. Feature Engineering, Dimension reduction- PCA, Regression Linear Model: Linear regression, logistic Regression.

Course Outcomes:

CO1: Understand basic concepts and visualize data to gain insight.

CO2: Apply data science skills to extract and interpret datasets

CO3: Analyse and interpret data using statistical models.

Text Book:

1. Sinan Ozdemir. Principles of Data Science: Learn the techniques and math you need to start making sense of your data. Packt Publishing.
2. VanderPlas, Jake. Python data science handbook: Essential tools for working with data. " O'Reilly Media, Inc.", 2023.

Reference Book:

1. Peng, Roger D., and Elizabeth Matsui. The Art of Data Science. A Guide for Anyone Who Works with Data. Skybrude Consulting, 2015.
2. Foreman, John W. Data smart: Using data science to transform information into insight. John Wiley & Sons, 2014.
3. Haider, Murtaza. Getting Started with Data Science: Making Sense of Data with Analytics. IBM Press, 2015.

Course Name: Engineering Thermodynamics **[3:0:0=3]**

Course Content:

Basic concepts: Zeroth law of thermodynamics; Energy Interactions: displacement and various other types of work,

First law of Thermodynamics: first law different systems, Energy - a property of the system, different forms of stored energy, enthalpy, and first law applied to flow processes.

Second Law of Thermodynamics: Heat Engines, Refrigerators and Heat pumps, Various statements of 2nd law and their equivalence, Reversibility and irreversibility, Carnot Cycle, Carnot's theorem, Clausius inequality.

Entropy: Definition, Principles of increase of entropy, calculation entropy for various processes.

Available energy and availability: Helmholtz and Gibbs functions, availability in steady flow, entropy equation for flow processes, irreversibility.

Properties of Pure Substances: p-V, p-T, T-s and h-s diagrams for a pure substance, application to vapour power cycles, quality, Steam Tables and charts for thermodynamics properties, measurement of steam quality;

Combined 1st and 2nd Laws: Maxwell relations, T-dS equations, Joule-Kelvin effect, Clausius-Clapeyron equation, Gibb's Phase rule and Conditions of stability.

Course Outcomes:

CO1: Understand the various laws of thermodynamics and other fundamental concepts for solving various engineering problems.

CO2: Compute the thermodynamic properties of substances in their gaseous and liquid phases.

CO3: Apply concepts of entropy, availability and combined 1st and 2nd laws of thermodynamics for solving engineering problems

Textbook:

1. Y.A.Cengel and M.A.Boles, *Thermodynamics: an Engineering Approach*, (8th edition), New York, McGraw Hill, 2015

Reference Book:

1. Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner and Margaret B. Bailey, *Fundamentals of Engineering Thermodynamics,* 8th edition, USA, Wiley, 2014.
2. P.K. Nag, *Engineering thermodynamics*, (6th edition) New Delhi, Tata McGraw Hill Company Ltd., 2017

Course Name: Engineering Materials **[3:0:2=4]**

Course Content:

Introduction- Classification of Materials, Advanced Materials; Fundamentals of Structures of Crystalline Solids. Crystal systems- Point Coordinates, Crystallographic Directions, Single Crystals, Polycrystalline Materials; Structure of Crystalline Solids-The FCC, BCC, HCP Crystal Structure, Density computations, Atomic Arrangements, Closed packed Crystal Structures; Imperfections in Solids- Vacancies and Interstitials, Impurities in solids, Dislocations-Linear Defects, Interfacial Defects, Bulk or Volume Defects, Nucleation and growth of solids – cooling curve analysis; Mechanical Properties of Metals- Introduction, Ferrous Alloys, Non Ferrous Alloys, Thermal Processing of Metals. Phase-diagrams: Gibbs Phase rule; Binary- Isomorphous, Eutectic, Eutectoid, Peritectic, Peritectoid; Fe-C phase diagram; lever-rule

Concepts of Stress or Strain, Elastic Deformation, Plastic Deformation, Hardness; Dislocations and Strengthening Mechanisms in Metals; Characteristics of dislocations, Slip Systems, Slip in Single Crystals, Deformation by Twinning, Strengthening by Grain size Reduction, Solid Solution Strengthening, Strain Hardening, Recovery, Recrystallization, Grain Growth, Precipitation Hardening; Failure of Metals-Fundamentals of Fracture, Ductile Fracture, Brittle Fracture; Applications and Properties of Ceramics-Glasses, Glass Ceramics, Clay products, Refractories, Abrasives, Cements, Advanced Ceramics; Composite Materials-Introduction, Large Particles, Composites, Dispersion strengthened Composites, Influence of Fiber Length, Influence of Fiber Orientation and Concentration, The Fiber Phase, The Matrix Phase, Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon Carbon Composites, Hybrid Composites

Develop new alloys through melting and casting experiments (location: Aluminium Research Lab), cooling-curve analysis (location: Aluminium Research Lab), metallography using polishing machine (location: Materials testing Lab), Examine the microstructures through Optical Microscopy (location: CAMD E2 bldg.), Tensile-testing/ Hardness testing/ Fatigue testing etc. (location: Materials testing lab). Heat-treatment of steels & Non-ferrous alloys (location: Materials testing lab) Optical & Scanning Electron Microscopy of the above alloys (location: CAMD E2 bldg.)

Course Outcomes:

CO1: Understand fundamental concepts on the corresponding topic

CO2: Analyse and solve specific problems in the respective topics

CO3: Design, synthesise and Analyse new alloys (materials-structure-property correlations)

Textbook:

1. "CALLISTER'S MATERIALS SCIENCE AND ENGINEERING (With CD)" 2016, Materials Science and Engineering: An Introduction, Eight Edition, John Wiley & Sons Inc. (Author: R. Balasubramaniam)

Reference Book:

1. "Materials Science and Engineering" - (Authors: William F Smith, Javad Hashemi and Ravi Prakash), 5th Edition; McGraw Hill Education (India) Pvt. Limited.
2. "Materials Science and Engineering", - (Author: V. Raghavan), ISBN-978-81-203-5092-2
3. “Materials selection in mechanical design”, 2006, , Fourth Edition, McGraw Hill Inc. (Author: Michael F Ashby)
4. “Introduction to Physical Metallurgy” McGraw Hill Education; 2 edition (1 July 2017), ISBN-10: 0074630067, ISBN-13: 978-0074630068