CURRICULUM

FOR

MECHANICAL ENGINEERING

SEMESTER - VI (MECHANICAL ENGINEERING)

S.No	Paper Code	Paper Title	L	T	P	Credits
1	PCC-ME 308	Design of Machine Elements	3	1	2	5
2	PCC-ME 306	Dynamics of Machinery	3	0	3	4.5
3	-	Graduate Employability Skills and Competitive Courses (GATE, IES, etc.)	3	0	0	0
4	PCC-ME 307	Manufacturing Technology	3	0	3	4.5
5	-	Open Elective- I	3	0	0	3
6	-	Program Elective- I	3	0	0	3
7	-	Program Elective- II	3	0	0	3

PAPER CODE - PCC ME 306

PCC-ME 306	Dynamics of Machinery	L:3	T:0	P:3	CREDIT:4.5

Objectives:

- To equip the student with fundamental knowledge of dynamics of machines so that students can appreciate problems of dynamic force balance, transmissibility of forces, isolation of systems, vibrations.
- Develop knowledge of analytical and graphical methods for calculating balancing of reciprocating masses.
- Develop understanding of vibrations and its significance on engineering design.
- Develop understanding of dynamic balancing, flywheel analysis, gyroscopic forces and Moments.

Detailed contents:

Module 1

Force analysis of mechanism: Dynamics of plane motion of a rigid body, dynamically equivalent two mass system, correction torque, forced in mechanism and machines.

Module 2

Turning moment diagram: Fluctuations of crankshaft speed and energy in a direct acting engine mechanism, flywheels.

Module 3

Cams: Classification of cams and followers, types of follower and retardation, cam profile and generation of concentric and offset radial cam profiles by graphical method. Cams with specified contours tangent cam with roller follower, circular arc cam with flat follower.

Module 4

Analysis of gyroscopic motion: Principle of gyroscope, gyroscopic couple and gyroscopic reaction couple, Gyroscopic effects on the movement of ships, aeroplanes, two wheeled and four wheeled vehicles, gyro stabilizers.

Module 5

Effects of inertia of reciprocating masses on engine frame: Unbalanced primary and secondary forces and couples, balancing of primary and secondary forces, partial balancing of locomotives,balancing of multi cylinder in-line and radial engines, direct and reverse cranks methods for balancing of radial engines.

Module 6

Mechanical vibrations: Basic concepts degree of freedom, types of damping and viscous damping; natural free, damped free and damped forced vibrations of a single degree of freedom spring mass system, reciprocating and rotating unbalance, vibration isolation and transmissibility, whirling of shaft, elementary treatment of two degree of freedom systems torsional vibrations of single rotor and two rotor systems, transverse vibration of simply supported beam energy method, Rayleigh and Dunkerley method.

Course outcomes:

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Upon successful completion of this course the student should be able to:

- ➔ Analyze stabilization of sea vehicles, aircrafts and automobile vehicles. ➔ Compute frictional losses, torque transmission of mechanical systems.
- ➔ Analyze dynamic force analysis of slider crank mechanism and design of flywheel.
- ➔ Understand how to determine the natural frequencies of continuous systems starting from the general equation of displacement. Understand balancing of reciprocating and rotary masses.

Text/References Books:

- ➔ Theory of Machines / S.S Rattan / Mcgraw Hill Publ.
- ➔ Mechanism and machine theory by Ashok G. Ambedkar, PHI Publications.
- ➔ Mechanism and Machine Theory / JS Rao and RV Dukkipati / New Age.
- ➔ Theory of Machines / Shigley / MGH
- ➔ Theory of Machines / Thomas Bevan / CBS Publishers ➔ Theory of machines / Khurmi / S.Chand.

Laboratory:

Minimum of 10 Experiment need to be performed

- ➔ To study various types of Links, Pairs, Chain and Mechanism
- ➔ To study inversion of Four Bar Mechanism
- ➔ To study velocity diagrams for Slider Crank Mechanism.
- ➔ To study various kinds of belt drives.
- ➔ To study and find coefficient of friction between belt and pulley.
- ➔ To study various types of Cam and Follower arrangement.
- ➔ To plot follower displacement Vs cam rotation graph for various cam follower arrangement.
- ➔ To study Different types of Gears.
- ➔ To study Different types of Gear Trains.
- ➔ To Perform Experiment on Watt, Porter, Proell and Hartnell Governors and prepare Performance Characteristic Curves also analyze Stability & Sensitivity
- ➔ To study gyroscopic effects through models.
- ➔ To determine a gyroscopic couple on a Motorized Gyroscope.
- ➔ To perform the experiment of Balancing of rotating parts and find the unbalanced couple and forces.

- ➔ To study Dynamically Equivalent Systems.
- ➔ Determine the moment of inertia of connecting rod by compound pendulum method and trifler suspension pendulum.
- ➔ To study the various types of dynamometers.
- ➔ To find out critical speed experimentally and to compare the Whirling Speed of a shaft with theoretical values.

PAPER CODE - PCC ME 307

PCC-ME 307	Manufacturing Technology	L:3	T:0	P:3	CREDIT:4.5

Objectives:

- ➔ To provide knowledge on machines and related tools for manufacturing various components.
- ➔ To understand the relationship between process and system in the manufacturing domain.
- ➔ To identify the techniques for the quality assurance of the products and the optimality of the process in terms of resources and time management.

Detailed contents:

Module 1

Tooling for conventional and non-conventional machining processes: Mould and die design, Press tools, Cutting tools; Holding tools: Jigs and fixtures, principles, applications and design; press tools – configuration, design of die and punch; principles of forging die design.

Module 2

Metrology: Dimensions, forms and surface measurements, Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; Metrology in tool wear and part quality including surface integrity, alignment and testing methods; tolerance analysis in manufacturing and assembly. Process metrology for emerging machining processes such as microscale machining, Inspection and workpiece quality.

Module 3

Assembly practices: Manufacturing and assembly, process planning, selective assembly, Material handling and devices.

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Module 4

Unconventional Machining Processes: Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultrasonic Machining, principles and process parameters. Electrical Discharge Machining, principle and processes parameters, MRR, surface finish, tool wear, Dielectric, power and control circuits, wire EDM;
Electro-chemical machining (ECM), etchant & maskant, process parameters, MRR and surface finish. Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining

Course Outcomes:

Upon completion of this course, students will be able to understand the tooling needed for manufacturing, the dimensional accuracy and tolerances of products, assembly of different components and the application of optimization methods in manufacturing.

Text Books:

Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)- PearsonIndia, 2014.

- ➔ Taha H. A., Operations Research, 6th Edition, Prentice Hall of India, 2003.
- ➔ Shenoy G.V. and Shrivastava U.K., Operations Research for Management, Wiley Eastern, 1994.

Laboratory:

- ➔ Measurement of angle using Sine Center / Sine bar / bevel protractor
- ➔ Measurement of alignment using Autocollimator / Roller set
- ➔ Measurement of cutting tool forces using ◆ Lathe tool Dynamometer
  ◆ Drill tool Dynamometer.
- ➔ Measurement of Screw Threads Parameters using Two wire or Three-wire method.
- ➔ Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
- ➔ Measurement of gear tooth profile using gear tooth Vernier/Gear tooth micrometer
- ➔ Calibration of Micrometer using slip gauges
- ➔ Measurement using Optical Flats

PAPER CODE - PCC ME 308

PCC-ME 308	Design of Machine Elements	L:3	T:1	P:2	CREDIT:5

Objectives:

This course seeks to provide an introduction to the design of machine elements commonly encountered in mechanical engineering practice, through

- ➔ A strong background in mechanics of materials based failure criteria underpinning the safety-critical design of machine components.
- ➔ An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations .
- ➔ An overview of codes, standards and design guidelines for different elements.
- ➔ An appreciation of parameter optimization and design iteration 5. An appreciation of the relationships between component level design and overall machine system design and performance.

Detailed contents:

Module 1

Introduction to design: Steps in design process, design factors, practical considerations in design, selection of materials, strength of mechanical elements, impact load, shock load, fatigue loading, effects of surface, size, temperature and stress concentration, consideration of creep and thermal stress in design.

Module 2

Design of shafts: stresses in shafts, design of static loads, combined stresses, reversed bending and steady loads, design of shafts based on deflection and strength, critical speed of shafts. Analysis and design of sliding and rolling contact bearings,

Module 3

Riveted joint: Stresses in riveted joint, design of riveted joints with central and eccentric loads, boiler and tank joints, structural joints. Bolt Joints:
Stresses in bolt joints, design of bolt joints with central and eccentric loads.
Welded joints: types of welded joints, stresses, design of welded joints subjected to axial, torsional and bending loads, welds subjected to fluctuating loads.

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Module 4

Design of Clutches: Friction clutches, uniform wear and uniform pressure assumptions, centrifugal clutches. Brakes: Design of internal expansion elements, assumptions, design of external contraction elements, band type brakes.

Module 5

Design of transmission elements: spur, helical, bevel and worm gears; Springs: stresses in helical springs, deflection of helical compression and tension springs, springs subjected to fatigue loading, concentric and helical torsion spring, critical frequency of springs, leaf springs, and design of automotive leaf springs.

Course Outcomes:

Upon completion of this course, students will get an overview of the design methodologies employed for the design of various machine components.

Data books allowed for Examination:

- ➔ Mahadevan & Balaveera Reddy : Design Data Hand Book
- ➔ Dr. Linghaigh & Prof. Narayana Iyengar, Vol.1 & 2 : Design Data Hand Book
- ➔ P.S.G. Tech : Design Data Hand Book **Text Books:**

- ➔ Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
- ➔ Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.
- ➔ Juvenile, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
  Spottes, M.F., Design of Machine elements, Prentice-Hall India, 1994.
- ➔ R. L. Norton, Mechanical Design – An Integrated Approach,

  Prentice Hall, 1998

Laboratory:

- ➔ To study the design procedure of Knuckle & Cotter joint.
- ➔ Design of shafts subjected to torsion, bending moment and combined bending and torsion.
- ➔ Design of flat and square key

- ➔ Design and drawing of riveted joints
- ➔ Design and drawing of screw jack
- ➔ Journal Bearing Test Rig

PROGRAM ELECTIVE

PAPER CODE - 105 701

105 701	Data Science	L:3	T:0	P:0	CREDIT:3

Objectives of the course:

The objective of this course is to impart necessary knowledge of the mathematical foundations needed for data science and develop programming skills required to build data science applications.

Detailed Contents:

Module 1

Introduction to Data Science: Concept of Data Science, Traits of Big data, Web Scraping, Analysis vs Reporting

Module 2

Introduction to Programming Tools for Data Science: Toolkits using Python:
Matplotlib, NumPy, Scikit-learn, NLTK; Visualizing Data: Bar Charts, Line Charts,
Scatterplots; Working with data: Reading Files, Scraping the Web, Using APIs
(Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction

Module 3

Mathematical Foundations: Linear Algebra: Vectors, Matrices; Statistics:
Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and
Causation; Probability: Dependence and Independence, Conditional Probability, Bayes's
Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem; Hypothesis and Inference: Statistical Hypothesis Testing, Confidence Intervals, P Hacking, Bayesian Inference

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Module 4

Machine Learning Overview of Machine learning concepts – Over fitting and train/test splits, Types of Machine Learning – Supervised, Unsupervised, Reinforced learning, Introduction to Bayes Theorem, Linear Regression- Model Assumptions,
Regularization (lasso, ridge, elastic net), Classification and Regression algorithmsNaïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, and random forest, Classification Errors, Analysis of Time SeriesLinear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks Learning And Generalization, Overview of Deep Learning.

Module 5

Case Studies of Data Science Application Weather forecasting, Stock market prediction, Object recognition, Real Time Sentiment Analysis.

Module 6.

List of Practicals

- ➔ Write a programme in Python to predict the class of the flower based on available attributes.
- ➔ Write a programme in Python to predict if a loan will get approved or not.
- ➔ Write a programme in Python to predict the traffic on a new mode of transport.
- ➔ Write a programme in Python to predict the class of user.
- ➔ Write a programme in Python to identify the tweets which are hate tweets and which are not.
- ➔ Write a programme in Python to predict the age of the actors.
- ➔ Mini project to predict the time taken to solve a problem given the current status of the user.

Reference Books:

- ➔ Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media
- ➔ Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow:
  Concepts, Tools, and Techniques to Build Intelligent Systems", 1st Edition, O'Reilly Media
- ➔ Jain V.K., "Data Sciences", Khanna Publishing House, Delhi.

- Jain V.K., "Big Data and Hadoop", Khanna Publishing House, Delhi.
- Jeeva Jose, "Machine Learning", Khanna Publishing House, Delhi.
- Chopra Rajiv, "Machine Learning", Khanna Publishing House, Delhi.
- Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press http://www.deeplearningbook.org
  Jiawei Han and Jian Pei, "Data Mining Concepts and Techniques", Third Edition, Morgan Kaufmann Publishers

PAPER CODE - 105 702

105 702	Computational Complexity	L:3	T:0	P:0	CREDIT:3

Detailed Contents:

Module 1

Models of Computation, resources (time and space), algorithms, computability, complexity.

Module 2

Complexity classes, P/NP/PSPACE, reductions, hardness, completeness, hierarchy, relationships between complexity classes.

Module 3

Randomized computation and complexity; Logical characterizations, incompleteness; Approximability.

Module 4

Circuit complexity, lower bounds; Parallel computation and complexity; Counting problems; Interactive proofs.

Module 5

Probabilistically checkable proofs; Communication complexity; Quantum computation.

Reference Books:

- Christos H. PapadimitriouCombinatorial Optimization: Algorithms and Complexity, Prentice-Hall.
- Sanjeev Arora and Boaz Barak, Complexity Theory: A Modern Approach, Cambridge University Press

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➔ Steven Homer, Alan L. Selman, Computability and Complexity Theory, Springer

PAPER CODE - 105 703

105 703	Advanced Computer Architecture	L:3	T:0	P:0	CREDIT:3

Detailed contents:

Module 1

Classes of computers, Trends in technology, power and costs, dependability, quantitative principles of computer design, Introduction to computing models.

Module 2

Principles of scalable performance, performance metrics and measures, speedup performance laws, advanced processor technology, super scalar and VLIW processors, Verified memory, cache memory organizations, shared memory organizations. Memory hierarchy, cache performance, protection and examples of virtual memory, cache coherence.

Module 3

Pipeline and superscalar techniques, linear pipeline processors, reservation and latency analysis, collision free scheduling, pipeline schedule optimization, instruction pipeline design, arithmetic pipeline design, super scalar and super pipeline design.

Module 4

Multiprocessors and multicomputers, Brief overview of SIMD, MIMD, vector architectures and multicore architectures.

Module 5

Elementary theory about dependence analysis, techniques for extraction of parallelism, branch prediction, dynamic scheduling, multiple issues and speculation, limits on instruction level parallelism, Thread level parallelism **Reference Books:**

- Computer Architecture: A Quantitative Approach : Hennessy and Patterson : Morgan Kaufmann
- Advanced Computer Architecture, Kai Hwang , McGraw Hill
- Advanced Computer Architectures: A design space approach, Sima D, Fountain T. and Kacsuk P, Pearson Education

PAPER CODE - 105 704

105 704	Theory of Computation	L:3	T:0	P:0	CREDIT:3

Detailed contents:

Logic: First-order predicate calculus - syntax, semantics, validity and satisfiability, decision problems in logic, quantified Boolean formulas and their relation with the polynomial hierarchy.

Computability theory: Review of Turing machines, some other computing models and formalisms, their equivalence with Turing machines, undecidability, Post correspondence problem, Turing computability, primitive recursive functions, Cantor and Goedel numbering, Ackermann function, mu-recursive functions, recursiveness of Ackermann and Turing computable functions, lambda calculus, term rewriting, oracle machines and the arithmetic hierarchy.

Complexity theory: Time- and space-bounded Turing machines, reduction and complete problems, oracle machines and the polynomial hierarchy, randomized computation, parallel computation.

Reference Books:

- Michael Sipser, Introduction to the Theory of Computation, PWS Publishing.
- Fred C. Hennie. Introduction to Computability. Addison-Wesley.
- Bernard M. Moret, The Theory of Computation, Pearson Education Asia.
- Christos H. Papadimitriou, Computational Complexity, Addison-Wesley Longman.
- Dexter C. Kozen, Automata and Computability, Undergraduate Texts in Computer Science, Springer.
- John Martin, Introduction to Languages and The Theory of Computation, Tata McGraw Hill.
- John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education Asia.

PAPER CODE - 105 705

105 705	Internet of things	L:3	T:0	P:0	CREDIT:3

Objectives of the Course:

The objective of this course is to impart necessary and practical knowledge of components of Internet of Things and develop skills required to build real-life IoT based projects.

Detailed contents:

Module 1

Introduction to IoT: Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT.

Module 2

Elements of IoT: Hardware Components – Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication. Protocols- MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

Module 3

IoT Application Development: Solution framework for IoT applicationsImplementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

Module 4

IoT Case Studies: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.

Suggested Books:

- ➔ Vijay Madisetti, Arshdeep Bahga, Ïnternet of Things, "A Hands on Approach", University Press
- ➔ Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs
- ➔ Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
- ➔ Jeeva Jose, "Internet of Things", Khanna Publishing House, Delhi
- ➔ Adrian McEwen, "Designing the Internet of Things", Wiley
- ➔ Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill

➔ Cuno Pfister, "Getting Started with the Internet of Things", O Reilly Media

Learning Outcomes:

➔ Understand internet of Things and its hardware and software components
➔ Interface I/O devices, sensors & communication modules
➔ Remotely monitor data and control devices
➔ Develop real life IoT based projects

PAPER CODE - 105 706

105 706	Natural Language Processing	L:3	T:0	P:0	CREDIT:3

Detailed contents:

Module 1

Sound: Biology of Speech Processing; Place and Manner of Articulation; Word Boundary Detection; Argmax based computations; HMM and Speech Recognition.

Module 2

Words and Word Forms: Morphology fundamentals; Morphological Diversity of Indian Languages; Morphology Paradigms; Finite State Machine Based Morphology;
Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields.

Module 3

Structures: Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Hybrid of Rule Based and Probabilistic Parsing; Scope Ambiguity and Attachment Ambiguity resolution.

Module 4

Meaning: Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors; Coreferences.

Module 5

Web 2.0 Applications: Sentiment Analysis; Text Entailment; Robust and Scalable Machine Translation; Question Answering in Multilingual Setting; Cross Lingual Information Retrieval (CLIR).

Reference Books:

- Jurafsky, Dan and Martin, James, "Speech and Language Processing", 2nd Edition, Prentice Hall, 2008
- Manning, Christopher and Heinrich, Schutze, "Foundations of Statistical Natural Language Processing", MIT Press, 1999
- Allen James, "Natural Language Understanding", 2nd edition, Benjamin Cumming, 1995
- Charniack, Eugene, "Statistical Language Learning", MIT Press, 1993

PAPER CODE - 105 707

105 707	E-Commerce and ERP	L:3	T:0	P:0	CREDIT:3

Detailed contents:

Module 1

Introduction to E- Commerce: Evolution of E-commerce, Advantage and Disadvantage of E Commerce, Roadmap of E-Commerce in India. Business Models of E-Commerce: Model Based On Transaction Party: B2B, B2C, C2B, C2C.

Module 2

E marketing: The scope of E-Marketing, Identifying Web Presence goals, Uniqueness of the web, Meeting the need of website visitors, Website Design Issues:
Factors that make People Return to Your Site, Strategies for Website Development. Site Adhesion: Content, format and access: maintaining a Website, E- Advertising, E-Branding

Module 3

E-Payment System: Digital Payment Requirement, Digital Token based E-Payment
System, Electronic Cash, Smart card and Electronics payment system: Credit and Debit
Card, Virtual Currency, Digital wallet, Risk of Electronics payment system, Digital Signature. E Security: Security On the Internet: Network and Website Security Risk:

Denial-of-Service attack, Viruses, Unauthorized access to computer Network. Security
Standards: Firewall, Cryptography, Key Management, Password Systems, Digital certificates, Digital signatures.

Module 4

Enterprise Resource Planning (ERP): Introductory Concepts, Advantages &
Disadvantages of ERP, ERP and Related Technologies: - Business Process Reengineering,
Data Warehousing, Data Mining, Supply Chain Management. ERP Implementation: ERP
Implementation Life Cycle –Implementation Methodology, Hidden Costs , Organizing
Implementation – Contracts with Vendors, Consultants and Users , Project Management and Monitoring.

Module 5

ERP Business Modules: Introduction to basic Modules of ERP System, Business
Modules in an ERP Package- Finance – Manufacturing – Human Resource – Plant Maintenance – Materials Management – Quality Management – Sales and Distribution.
Case Study: Recent business issues on E-Commerce Perspective. Text Books: 1. Alexis Leon, "ERP Demystified", Tata McGraw Hill. 2. E-Commerce An Indian Perspective by
P.T.Joseph, PHI

Reference Books:

- K.K. Bajaj, D. Nag "E-Commerce", 2nd Edition, McGraw-Hill Education, New Delhi.
- Bhaskar Bharat, "Electronic Commerce-Technology and Application", McGraw-Hill Education, New Delhi.
- Mary Sumner, "Enterprise Resource Planning", 2005, PHI Learning India Pvt. Ltd. /Pearson Education, New Delhi.
- Chan, "E-Commerce fundamentals and Applications", Wiley India, New Delhi.
- Vinod Kumar Garg and N.K .Venkata Krishnan, "Enterprise Resource Planning – concepts and Planning", Prentice Hall, 1998.

PAPER CODE - 105 708

105 708	Robotics and Robot Application	L:3	T:0	P:0	CREDIT:3

Objective of the Course:

The objective of this course is to impart knowledge about industrial robots for their control and design.

Detailed contents:

Module 1

Introduction to Robotics: Types and components of a robot, Classification of robots, closed-loop and open loop control systems. Kinematics systems; Definition of mechanisms and manipulators, Social issues and safety.

Module 2

Robot Kinematics and Dynamics: Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics. Dynamic Modelling: Equations of motion: Euler-Lagrange formulation.

Module 3

Sensors and Vision System: Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc., Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean / Similarity / Affine / Projective transformations. Vision applications in robotics.

Module 4

Robot Control: Basics of control: Transfer functions, Control laws: P, PD,
PID. Non-linear and advanced controls. Robot Actuation Systems: Actuators: Electric,
Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

Module 5

Control Hardware and Interfacing: Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications.

Suggested Books:

- Saha, S. K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.
- Ghosal, A., "Robotics", Oxford, New Delhi, 2006.
- Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", PHI, New Delhi.
- Mittal R.K. and Nagrath I.J., "Robotics and Control", Tata McGraw Hill.
- Mukherjee S., "Robotics and Automation", Khanna Publishing House, Delhi.
- Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, New Delhi, 2009
- Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modelling and Control", John Wiley and Sons Inc, 2005
- Steve Heath, "Embedded System Design", 2nd Edition, Newnes, Burlington, 2003
- Merzouki R., Samantaray A.K., Pathak P.M. and Bouamama B. Ould, "Intelligent Mechatronic System: Modeling, Control and Diagnosis", Springer.

Learning Outcomes:

- Perform kinematic and dynamic analyses with simulation.
- Design control laws for a robot.
- Integrate mechanical and electrical hardware for a real prototype of a robotic device.
- Select a robotic system for a given application.

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