I SEMESTER

15PM01 LINEAR SYSTEMS THEORY

VECTOR SPACES: Vector spaces, subspaces, linear independence, basis and dimension, row space, column space and null space, inner product space, orthonormal bases, Gram-Schmidt process, eigenvalues and eigenvectors, diagonalization. (7+7)

LINEAR TRANSFORMATIONS: Linear transformations, kernel and range, inverse linear transformations, matrices of linear transformations, quadratic forms, diagonalizing quadratic forms. (5+5)

STATE SPACE LINEAR SYSTEMS: State space linear systems, block diagrams, linearization of nonlinear systems. (2+2)

SOLUTION TO STATE EQUATIONS: Linear time variant (LTV) system, linear time invariant (LTI) system, solution to homogeneous system, solution to nonhomogeneous system, solving continuous time system. (4+4)

SYSTEM STABILITY: The concept of an equilibrium, Lyapunov stability, eigenvalue conditions for Lyapunov stability, Lyapunov stability theorem, BIBO stability, time domain conditions for BIBO stability, BIBO versus Lyapunov stability. (3+3)

CONTROLLABILITY: Controllable and reachable subspaces, reachability and controllability gramians, controllability matrix (LTI), controllable systems, eigenvector test for controllability, Lyapunov test for controllability. (3+3)

OBSERVABILITY: Motivation - output feedback, unobservable subspaces, unconstructible subspace, observability and constructability Gramians, observability tests. (3+3)

MINIMAL REALIZATIONS: Minimal realizations, Markov parameters, similarity of minimal realizations, order of a minimal SISO realization. (3+3)

REFERENCES:

Total L: 30 + T: 30 = 60

15PM02 CONCEPTS OF DIGITAL MANUFACTURING

INTRODUCTION TO DIGITAL MANUFACTURING: Definition of digital manufacturing, Operation Mode and Architecture of Digital Manufacturing System. (3)

CAD MODELING: Design process and role of CAD, Types and applications of design models, Three dimensional modeling schemes, Wire frames and surface representation schemes, Solid modeling - Parametric modeling, Assembly modeling. (9)

REVERSE ENGINEERING: Need, Reverse engineering process, Reverse engineering hardware and software, Geometric model development. (5)

COMPUTER AIDED MANUFACTURING: Component modeling, Machine and tool selection, Defining process and parameters, Tool path generation, Simulation, Post processing. (6)

CONCEPT MODELERS: Introduction, Principle, Thermo jet printer, Sander's model market, 3-D printer, Genisys Xs printer, JP system 5, object quadra system-Rapid prototyping. (5)

DIGITAL FACTORY AND VIRTUAL MANUFACTURING: Introduction, Scope, Methods and Tools Used in Virtual Manufacturing, Benefits. Virtual factory simulation. (5)

PRODUCT LIFE CYCLE MANAGEMENT: Introduction, Types of Product Data, PLM systems, Features of PLM System, System architecture, Product information models, Functionality of the PLM Systems. (6)


487
TUTORIAL SESSION: 3D Modeling of Engineering components and assemblies in CAD software, Machining simulation using CAM software, Reverse Engineering using microscribe.

REFERENCES:

15PM03 VIRTUAL REALITY SYSTEMS


HARDWARE TECHNOLOGIES FOR 3D USER INTERFACES: Visual Displays Auditory Displays, Haptic Displays, Choosing Output Devices for 3D User Interfaces.

3D USER INTERFACE INPUT HARDWARE: Input device characteristics, Desktop input devices, Tracking Devices, 3D Mice, Special Purpose Input Devices, Direct Human Input, Home - Brewed Input Devices, Choosing Input Devices for 3D Interfaces.


ADVANCES IN 3D USER INTERFACES: 3D User Interfaces for the Real World, AR Interfaces as 3D Data Browsers, 3D Augmented Reality Interfaces, Augmented Surfaces and Tangible Interfaces, Agents in AR, Transitional AR-VR Interfaces - The future of 3D User Interfaces, Questions of 3D UI Technology, 3D Interaction Techniques, 3D UI Design and Development, 3D UI Evaluation and Other Issues.


REFERENCES:

Total L: 45

Total L: 45 + T: 30 = 75
15PM04 COMPUTER GRAPHICS FOR VIRTUAL REALITY I


OpenGL GRAPHICS PROGRAMMING: The OpenGL API, Primitives and Attributes, Color, Control functions, Adding Interaction.

VIEWING: Positioning of the Camera, Parallel Projections, Perspective Projections, OpenGL Projection Matrices.


VERTICES TO FRAGMENTS: Basic Implementation Strategies, Four Major Tasks, Clipping - Line Clipping, Polygon Clipping, Clipping of Other Primitives, Clipping in Three Dimensions, Polygon Rasterization, Hidden-Surface Removal, Antialiasing, Display Considerations.


HIERARCHICAL MODELING: Symbols and Instances, Hierarchical Models, A Robot Arm, Trees and Traversal, Use of Tree Data Structures, Other Tree Structures, Scene Graphs, Open Scene Graph.

TUTORIAL COMPONENT:
1. Drawing basic 2D and 3D primitives in OpenGL.
2. Implementation of various parallel and perspective projections for simple 3D objects.
3. Implementation of 2D transformations: Translation, Scaling, Rotation, and Shearing
4. Implementation of 3D transformations: Translation, Scaling, and Rotation
5. Line clipping and Polygon Clipping using algorithms.
7. Simulation of various lighting and shading models.

Note: Algorithms in the Computer Graphics have to be implemented by the student using OpenGL.

Total L: 30 + T: 30 = 60

REFERENCES:

15PM05 GEOMETRIC MODELING AND COMPUTER AIDED DESIGN
Vide Product Design and Commerce 15PD04

15PM55 / 15PD55 OBJECT COMPUTING AND DATA STRUCTURES LABORATORY
Vide Manufacturing Engineering 15PP55

15PM61 INDUSTRY VISIT & TECHNICAL SEMINAR

The student will make at least two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits. A quiz covering the above will be held at the end of the semester.

Total P: 30
II SEMESTER

15PM06 COMPUTER GRAPHICS FOR VIRTUAL REALITY II


ADVANCED RENDERING: Going Beyond Pipeline Rendering - Ray Tracing - Building a Simple Ray Tracer - The Rendering Equation - Radiosity - RenderMan - Parallel Rendering - Volume Rendering - Isosurfaces and Marching Cubes - Mesh Simplification - Direct Volume Rendering - Image-Based Rendering. (6)

FRACTALS: Modeling - Sierpinski Gasket - Coastline Problem - Fractal Geometry - Fractal Dimension - Recursively defined curves - Koch curves - C curves - Dragons - Space filling curves - Turtle graphics - Grammar based models - Fractals - Volumetric Examples - k-midpoint subdivision - Fractal Brownian Motion - Fractal Mountains - Iteration in the Complex plane - Mandelbrot Set. (4)

COMPUTER ANIMATION: Design of Animation Sequences - General Computer - Animation - Functions - Raster Animations - Computer - Animation Languages - Key-Frame Systems - Motion Specifications, Kinematics & Dynamics. (4)

VIRTUAL REALITY MODELLING LANGUAGE: Introduction, exploring and building a world, building object, lighting, sound and complex shapes, animation and user interaction, colors, normals and textures, nodes references. Special Applications: Stereo display programming, multiport display systems, multi screen display system, fly mode navigation, walk through navigation, virtual track ball navigation.

TUTORIAL COMPONENT:
1. Construct the primitives with different color models and simulate the conversion from one model to another.
2. Develop a new texture and apply various mapping on 3D objects.
3. Illustrate the aliasing and anti-aliasing techniques.
4. Implementation of ray tracing concepts with the collection of 3D models.
5. Generation of fractal curves and landscapes using algorithms.
7. Develop an animation sequence to illustrate the concepts of kinematics and dynamics.
8. Build a 3D scene using VRML and explore it using various renderings. (30)

Note: Algorithms in the Computer Graphics have to be implemented by the student using OpenGL/VRML (Whichever is applicable)

Total L: 30 + T: 30 = 60

REFERENCES:

15PM07 MODELING AND SIMULATION OF VIRTUAL SYSTEMS

INTRODUCTION: Building a VR system, 3D multi modal interaction, VR software in modeling and simulation of engineering systems - use of discrete event simulation. (4)

MODELING: Modeling an object, scene construction, reference frames, modeling of function and behavior, estimating the performance of system, LOD, tuning the system. (11)

15PM08 PRODUCT LIFECYCLE MANAGEMENT
vide Product Design and Commerce 15PD06

15PM09 MATHEMATICAL MODELING AND COMPUTER AIDED ENGINEERING

INTRODUCTION: Problems in Engineering-Structural - Fluid flow and Heat transfer with their relevance in product development - examples - Need for computer aided engineering. (3)

PARTIAL DIFFERENTIAL EQUATIONS: Elliptic, parabolic and hyperbolic - physical significance - Solution techniques. (5)

NUMERICAL METHODS TO SOLVE PDEs: Central differences, Crank-Nicolson and ADI methods - examples - Stability and error of numerical schemes. (6)

VARIATIONAL CALCULUS: Introduction, Solutions selected differential equations by variational methods, Rayleigh - Ritz method - Introduction to Finite element method. (6)

FINITE ELEMENT METHOD: Concepts, nodes, elements, connectivity, Coordinate systems, shape functions, stiffness matrix, Global stiffness matrix, Isoparametric elements solution methods – Examples- Use of software . (8)

FLUID FLOW: Introduction to computational fluid dynamics (finite difference, finite element techniques) - Formulation of fluid flow problems (simple cases only) - Navier-Stokes equation - solution techniques - examples, solution of fluid flow problems using software. (6)

HEAT TRANSFER: Derivation of energy equation in general form - Solutions using numerical methods (finite difference and finite element techniques), solutions using FEA and CFD techniques for conductive and convective heat transfer problems. (8)

INTRODUCTION TO MULTI-PHYSICS PROBLEMS: Electrophoresis, electro-osmosis, lab-on – chip used in biotechnology Use of software. (3)

TUTORIAL COMPONENT: (30)

REFERENCES:

Total L: 45 + T: 30 = 75
15PM10 SCIENTIFIC AND ENGINEERING DATA VISUALIZATION  

VISUALISATION - Scientific and engineering perspective - Impact of Visualisation in product design, an overview of computer graphics for visualization – Types of data for visualization, Introduction to tensors, role of preprocessor, solver and post processor in solving engineering problems

OVERVIEW OF MASSIVE DATA VISUALIZATION: Simplification methods, Multi-resolution methods, External memory methods, Visual scalability.

SCALAR VISUALISATION TECHNIQUES: Visualization Goals, Representation of mesh and results data, mapping analysis results to Visualisations, One dimensional, two dimensional and three dimensional Scalar fields - Element face colour coding - contour display - isosurface techniques - Marching Cubes algorithm - Particle sampling.


CONTINUUM VOLUME DISPLAY: Volume rendering Terminology, Surface and Volume rendering techniques, Optimisation.

APPLICATIONS OF ENGINEERING VISUALISATION: Case studies created in the laboratory


Total L: 45

REFERENCES:

15PM51 VIRTUAL MODELING AND SIMULATION LABORATORY  

In this course, students will be provided with an orientation programme on the following equipment/software for a duration of 20 hours. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, state of technology/knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used (from the orientation programme), results from the experiments and their interpretation with respect to the assumptions/background and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 40 hours.

Topics for orientation programme
1. Introduction to virtual reality hardware. (Projectors, Gloves, Glasses and other Peripherals.)
2. Introduction to VR software. (Software architecture, Components, Third party products.)
3. Conversion of CAD models into VR models.
4. Adding behavior to CAD models.
5. Use of VR hardware peripherals (Glass, Glove etc.) for immersive effect.

Total P: 60

III SEMESTER

15PM52 VIRTUAL PROTOTYPING AND DESIGN LABORATORY  

In this course, students will be provided with an orientation programme on the following equipment/software for a duration of 20 hours. After this orientation, each student is expected to formulate and complete an activity of interest which has to be derived from the orientation programme under the guidance of a faculty. The details like background, problem definition, state of technology/knowledge in that area by a good literature review (5 latest papers), objectives, methodology, equipment that can be used (from the orientation programme), results from the experiments and their interpretation with respect to the assumptions/background
and a formal conclusion are expected in the report which is to be submitted at the end of the semester. This work is evaluated for the credit assigned. Expected hours needed for this work is 40 hours.

**Topics for orientation programme**

1. Creation of assemblies of products in VR.
2. Conversion of assemblies to VR models.
3. Creation of digital mockup addition of behavior.
4. Ergonomic and aesthetic studies.
5. Creation of a full fledged immersive environment for product / system evaluation.

Total P: 60

**15PM71 PROJECT WORK - I**

1. Identification of a real life problem in thrust areas
2. Developing a mathematical model for solving the above problem
3. Finalisation of system requirements and specification
4. Proposing different solutions for the problem based on literature survey
5. Future trends in providing alternate solutions
6. Consolidated report preparation

**IV SEMESTER**

**15PM72 PROJECT WORK - II**

The project work involves the following:

I. Preparing a project - brief proposal including
   1. Problem Identification
   2. A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
   3. List of possible solutions including alternatives and constraints
   4. Cost benefit analysis
   5. Time Line of activities

II. A report highlighting the design finalization [based on functional requirements and standards (if any)]

III. A presentation including the following:
   1. Implementation Phase (Hardware / Software / both)
   2. Testing and Validation of the developed system
   3. Learning in the Project

IV. Consolidated report preparation

**ELECTIVE THEORY COURSES**

**15PM21 SIMULATION AND MODELLING TECHNIQUES**

**INTRODUCTION TO SIMULATION:** Advantages and disadvantages of simulation, areas of application, systems and system environment, components of a system, discrete and continuous system, model of a system, types of models.

**RANDOM NUMBER GENERATION:** Properties of random numbers, Techniques for generating random numbers, linear congruential method, combined linear congruential generators, random number streams, midsquare method, feedback shift register generators, tests for random numbers , frequency tests - the Kolmogorov_Smirnov test, the Chi-square tests.
RANDOM VARIATE GENERATION: Inverse transform technique, exponential distribution, uniform distribution, Weibull distribution, empirical continuous distributions, empirical discrete distribution, discrete uniform distribution, geometric distribution, acceptance-rejection technique, Poisson distribution, gamma distribution, discrete transformation for the normal and lognormal distributions, convolution method. (7)

INPUT- OUTPUT MODELLING: Data collection, identifying the distribution with data, parameter estimation, goodness of fit tests. Verification and validation, verification of simulation models, calibration and validation of models. Types of simulations with respect to output analysis, Stochastic nature of output data, measures of performance and their estimation, output analysis of terminating simulations. (6)

SIMULATION OF QUEUEING SYSTEMS: Simulation of a single server queue, simulation of a two server queue, simulation of more general queues. (3)

INVENTORY CONTROL: Elements of inventory theory, more complex inventory models, simulation of inventory control. (2)

SIMULATION LANGUAGES: GPSS, SIMSCRIPT, SIMULA, SIMUL 8. (2)

CASE STUDIES: Simulation of manufacturing and material handling system, simulation of computer systems, simulation of computer networks. (2)

TUTORIAL COMPONENT:

REFERENCES:

15PM22 HUMAN COMPUTER INTERACTION

USABILITY OF INTERACTIVE SYSTEMS: Goals and Measures - Motivations, Universal Usability, Goals for Profession, Guidelines, Principles and Theories. (4)


INTERACTION STYLES: Direct Manipulation and Virtual Environments - Examples of Direct Manipulation, Discussion of Direct Manipulation-3D Interfaces, Teleportation, Virtual and Augmented Reality. Overview of Menu Selection, Form Fill-in and Dialog Boxes - Command and Natural Languages. (7)


INFORMATION SEARCH: Searching in Textual Documents and Database Querying, Multimedia Document Searches, Advanced Filtering and Search Interfaces. Information Visualization, Introduction: Data Type by Task Taxonomy, Challenges for Information Visualization. (6)

CASE STUDY: Human computer interaction in industrial applications. (6)

REFERENCES:

Total L: 60

15PM23 OBJECT ORIENTED ANALYSIS AND DESIGN  
vide Product Design and Commerce 15PD25

15PM24 MECHATRONICS SYSTEM  
vide Manufacturing Engineering 15PP30

15PM25 DATABASE MANAGEMENT SYSTEMS  
vide Product Design and Commerce 15PD21

15PM26 ENTERPRISE COMPUTING  
vide Product Design and Commerce 15PD23

15PM27 IMAGE PROCESSING AND MACHINE VISION  
vide Manufacturing Engineering 15PP29

ONE CREDIT COURSES

For the detailed Syllabi of all the one credit courses offered by Production Engineering department which are listed in this programme scheme refer to the syllabi of M.E Manufacturing Engineering programme.

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.