Bansilal Ramnath Agarwal Charitable Trust's

VISHWAKARMA INSTITUTE OF TECHNOLOGY, PUNE – 37

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

BOOKLET FOR MULTIDISCIPLINARY MINOR SUBJECTS

Sr. No.	Department	Minor Course Name	Subject Code	Available Seats
1	AI&DS	Augmented Reality and Virtual Reality(ARVR)	AIM001	144
2	AI&DS	Image Processing	AIM002	144
3	AI&DS	Computer Graphics	AIM003	144
4	Chemical	Nanoscience and Nanotechnology	CHM001	30*
5	Chemical	Biology and Engineering	CHM002	30*
6	Civil	Climatology	CVM001	71
7	Computer	Discrete Structures and Graph Theory	CSM001	936
8	CS-AI	Discrete Mathematics	CIM001	436
9	CS-AIML	Discrete Mathematics	MLM001	450
10	CS-CBI	Internet of Things	CBM001	215
11	CS-DS	Data Visualization	DSM001	206
12	CS-SE	Agile Principles and Methodology	SEM001	215
13	ETC	IOT for Smart Applications	ETM001	212
14	ETC	Microcontroller and Applications	ETM002	211
15	INSTRU	Sensor And Automation	ICM001	98
16	INSTRU	Microcontroller and Applications	ICM002	98
17	IT	IOT And Cloud	ITM001	77
18	IT	Ethical Hacking	ITM002	77
19	IT	Computer Graphics	ITM003	77
20	IT	Augmented Reality and Virtual Reality	ITM004	77
21	IT	Automated Software Testing	ITM005	77
22	IT	Management Information Systems	ITM006	77
23	MECH	Digital Crafting Techniques	MEM001	83
24	MECH	Product Design and Development	MEM002	83
25	MECH	Automobile Systems	MEM003	83
26	MECH	Thermal Systems	MEM004	83
27	MECH	Power Plant Engineering	MEM005	82

*If all seats for these subjects are not filled, then 2nd choice of subject will be offered to students who have selected these subjects as 1st choice.

Multidisciplinary Minor

AIM001: Augmented Reality and Virtual Reality

Teaching Scheme: **Total Credits**: 3 Credits
Theory: 2 Hours / Week
Tutorial :1 Hours / Week

Course Objectives –

1. To Understand immersive technologies, their taxonomy, tools, applications, and distinguish AR, VR, and MR.
2. To Learn core concepts, hardware, and development lifecycle of Virtual Reality systems.
3. To gain practical knowledge of VR application development using tools like Unity, Unreal Engine, and Blender, including basic scripting and templates.
4. To comprehend Augmented Reality principles, types, and image processing techniques
5. To familiarize with AR development tools such as Vuforia and Unity, addressing challenges and real-world AR application deployment
6. To explore Mixed Reality technologies, their use cases, security challenges, and technical requirements for MR application development

Section I

Unit 1: **Introduction** - (5 Hours)
Immersive Basics, taxonomy, methods and techniques, tools, introduction to Virtual Reality, Augmented Reality and Mixed Reality, spectrum, difference between AR/VR/MR, Applications of AR/VR/MR, Online and Offline tools for AR/VR/MR, Consequences of Excessive AR/VR/MR.

Unit 2: **Virtual Reality** - (5 Hours)
Basics of Virtual Reality, Types, Augmented Reality, Head Mounted Device (HMD), Types and working along with different applications, Collaborative VR, Key components and benefits, VR Application Development Cycle, Comparison with Software Development Life Cycle, Web VR, Mobile VR. Tools, Use cases, Evolution of VR technology, Tools and Technologies for VR app development.

Unit 3: **Virtual Reality App Development** - (4 Hours)
Introduction to Virtual Reality App development, Software's, Unity, Blender, Unreal Engine, Blueprint, Types, Templates in Unreal Engine development, Basics of Unity and, introduction to game development using unity.

Section II

Unit 4: **Augmented Reality** - (5 Hours)
Introduction to Augmented Reality, types, mobile AR/ Web AR-headset AR, working principle, image processing principles in AR app, Basics of image processing, feature points detection, Key point detection, Key point description.

Unit 5: **Augmented Reality App Development** - (5 Hours)
Tools and technologies for AR app development, Vuforia, Vuforia engine, functions, Vuforia and Unity, challenges of AR app development, Applications of Augmented Reality in real world scenarios.

Unit 6: **Mixed Reality** - (4 Hours)
Mixed Reality basics, Technological requirement in development and deployment of MR apps, Security issues with MR apps. Mixed Reality applications. Use case of mixed reality.

Tutorials

1. Understanding Immersive Technology and Its Basics
2. Real-World Applications and Consequences of AR/VR/MR
3. Augmented Reality vs. Virtual Reality – A Conceptual Comparison
4. VR Development Lifecycle and Comparison with SDLC
5. Collaborative Virtual Reality – Concepts and Benefits
6. Unity and Unreal Engine Templates and Programming Basics
7. Basics of Image Processing in AR – Feature and Key point Detection
8. Role of Generative AI in Virtual and Augmented Reality Content Creation
9. Generative AI for Real-Time Avatar and Scene Generation in Immersive Systems
10. Ethics, Security, and Challenges of Generative AI in AR/VR/MR

Textbooks

1. **Tony Parisi, Learning Virtual Reality:** Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, Wiley, 2015.
2. **Murray Ramirez, Virtual Reality for Beginners:** How to Understand, Use & Create with VR, by, 2016.
3. **Roger Froze, Augmented Reality for Beginners:** Principles & Practices for Augmented Reality & Virtual Computers, 2016

Reference Books and E-Resources

1. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, 3D User Interfaces, Theory and Practice, Addison Wesley, USA, 2005.
2. Oliver Bimber and Ramesh Raskar, Spatial Augmented Reality: Merging Real and Virtual Worlds, 2005.

Example - H. Schmidt-Walter, R. Kories; 'Electrical Engineering. A Pocket Reference'; Artech House, 2007. Accessed: Oct. 16, 2016. [Online]. Available: https://ebookcentral.proquest.com

For MOOCs and other learning Resources

1. https://www.deepar.ai/demos
2. https://app.vectary.com/
3. https://builtin.com/articles/what-is-webar

Course Outcomes

1. Describe the key concepts and applications AR/VR/MR.
2. Describe the Virtual Reality concepts clearly.
3. Create application development using Virtual Reality.
4. Create and demonstrate development using Augmented Reality
5. Develop and deploy 3D AR/VR models
6. Understand advances in Mixed Reality.

CO - PO Mapping:

Multidisciplinary Minor Course

AIM002: Image Processing

Credits: 3 **Teaching Scheme Theory: 2 Hours/Week**

Course Objectives:

1. To understand the basics of digital images, colour models, and image formats.
2. To apply enhancement techniques in spatial and frequency domains.
3. To learn segmentation and feature extraction methods.
4. To study image compression techniques and their applications.
5. To use image transforms for image analysis and processing.
6. To apply image processing methods to real-time problem solving.

Theory Syllabus

Unit 1: Introduction to Image processing (5 Hours)

Introduction, Elements of image processing system, Scenes and Images, Vector Algebra, Human Visual System, colour vision colour model: RGB, HVS, YUV, CMYK, YC_bC_r and some basic relationships between pixels, linear and nonlinear operations. Image types (optical and microwave), Image file formats (BMP, tiff, jpeg, ico, ceos, GIF, png, raster image format). Image sampling and quantization.

Unit 2: Image Enhancement (5 Hours)

Thresholding, Spatial domain techniques { Image Negative, Contrast stretching, Grey level slicing, bit plane slicing, histogram and histogram equalization, local enhancement technique, image subtraction and image average, Image Smoothening: low-pass spatial filters, median filtering, Image Sharpening: high-pass spatial filter, derivative filters, Frequency domain techniques- Ideal low-pass filter, Butterworth low-pass filter, High-pass filter, Homo-morphic filters.

Unit 3: Image Analysis (5 Hours)

Image segmentation- Classification of image segmentation techniques: Watershed Segmentation, Edge-based Segmentation, region approach, clustering techniques, edge-based, classification of edges and edge detection, watershed transformation Feature Extraction- Boundary representation (Chain code, B-spline

representation, Fourier descriptor) Region representation (Area, Euler number, Eccentricity, Shape matrix, moment-based descriptor), texture-based features.

Unit 4: Image Compression (4 Hours)

Introduction to Image compression and its need, Coding redundancy, classification of compression techniques (Lossy and lossless- JPEG, RLE, Huffman, Shannon fano), scalar and vector quantization

Unit 5: Object recognition (4 Hours)

Need of Object Recognition, Automated object recognition system, pattern and pattern class, relationship between image processing and object recognition, approaches to object recognition.

Unit 6: Image Transform (5 Hours)

Introduction to two dimensional orthogonal and unitary transforms, properties of unitary transforms. One-two dimensional discrete Fourier Transform (DFT). Cosine, Slant, KL, affine transforms. Singular Value Decomposition, Applications of transforms in Image processing.

Laboratory

List of Experiments

1. Write MATLAB code to display following binary images
   Square, Triangle, Circle

   - Write MATLAB code to perform following operations on images
   - Flip Image along horizontal and vertical direction.
   - Enhance quality of a given image by changing brightness of image.
   - Image negation operation.
   - Change contrast of a given Image.

2. Write MATLAB code to implement pseudo colouring operation of a given image. Write MATLAB Code for Pseudo Colour of Image by using Gray to colour transform.

3. Study of different file formats e.g. BMP, TIFF and extraction of attributes of BMP.

4. Write MATLAB code to find following statistical properties of an image.

   - Mean
   - Median
   - Variance

- Standard deviation
- Covariance.

5. Write MATLAB code to enhance image quality by using following techniques

- Logarithmic transformation
- Histogram Equalization
- Gray level slicing with and without background.
- Inverse transformation.

6. Read an Image and Perform singular value decomposition. Retain only k largest singular values and reconstruct the image. Also Compute the Compression ratio.

7. Write MATLAB code to enhance image quality by using following techniques

- Low pass and weighted low pass filter.
- Median filter.
- Laplacian mask.

8. Write MATLAB code for edge detection using Sobel, Prewitt and Roberts operators.

9. Write C-language code to find out Huffman code for the following word COMMITTEE.

10. Write MATLAB code to design encoder and decoder by using Arithmetic coding for the following word MUMMY. (Probabilities of symbols M-0.4, U-0.2, X-0.3, Y- 0.1).

11. Write MATLAB code to find out Fourier spectrum, phase angle and power spectrum of binary image and grey scale image.

12. Develop an AI-inspired image stylization and enhancement system using classical image processing techniques. (GenAI based)

List of Tutorials

1) Introduction to image processing tools and environment setup using Python or MATLAB.
2) Reading, displaying, and basic manipulation of images including colour space conversions.
3) Image sampling and quantization with analysis of resolution and bit depth effects.
4) Spatial domain enhancement techniques like contrast stretching and histogram equalization.
5) Fourier Transform and frequency domain filtering for image analysis.
6) Noise addition and image restoration using mean, median, and inverse filtering.
7) Edge detection and morphological operations such as dilation and erosion.

8) Image compression techniques and colour-based segmentation using the HSI model.

Course Outcomes

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

1. Describe various image models and their properties.
2. Apply spatial filtering techniques for image enhancement.
3. Identify and implement image segmentation techniques.
4. Apply appropriate lossless and lossy compression methods.
5. Implement basic object recognition techniques.
6. Use image transforms to analyse and process digital images.

TEXTBOOKS:

1. Rafael C. Gonzalez, Richard E. Woods, 'Digital Image Processing', Pearson, Third Edition,2010.
2. Anil K. Jain, 'Fundamentals of Digital Image Processing', Pearson, 2002

REFERENCES

1. Kenneth R. Castleman, 'Digital Image Processing', Pearson, 2006.
2. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, 'Digital Image Processing using MATLAB', Pearson
Education, Inc., 2011.
3. D, E. Dudgeon and RM. Mersereau, 'Multidimensional Digital Signal Processing', Prentice Hall Professional
Technical Reference, 1990
4. William K. Pratt, 'Digital Image Processing', John Wiley, New York, 2002
5. Milan Sonka et al 'Image processing, analysis and machine vision', Brookes/Cole, Vikas Publishing House, 2nd
edition, 1999.

Multidisciplinary Minor

AIM003: Computer Graphics

Teaching Scheme: **Total Credits**: 3 Credits
Theory: 2 Hours / Week

Course Objectives –

1. To understand the fundamentals and applications of computer graphics.
2. To study graphics hardware and the graphics pipeline.
3. To implement algorithms for drawing and transforming 2D/3D objects.
4. To explore concepts of projections, shading, and visibility.
5. To introduce animation techniques and graphics programming tools.

Section I

Unit 1: **Introduction to Computer Graphics**- (5 Hours)
Definition, history and scope of computer graphics, pixel, Pixel dimensions, Typical graphics pipeline (CPU → GPU) and rendering equation, **Graphics file formats** – raster (BMP, PNG, JPEG, GIF, TIFF), vector (SVG), 3-D (OBJ, FBX, glTF), compression basics, Framebuffer concept, Colour Models and Pixel Colour ,(RGB, CMYK, HSL,HSV colour models) Raster-scan vs. random-scan systems,

Unit 2: **Output Primitives & Attributes**- (5 Hours)

Scan-conversion of basic primitives- DDA and Bresenham line algorithms (integer & floating-point forms), Mid-point circle, **Polygon rasterization** – scan-line algorithm, inside-outside tests, edge tables, **Area-fill algorithms** – boundary-fill, flood-fill, seed-fill variants, **Primitive attributes** –intensity mapping, point/line styles, area patterns**, Anti-aliasing** – super-sampling, area sampling, Wu's algorithm, gamma correction basics

Unit 3: **2-D Geometric Transformations & Viewing**- (5 Hours)
Homogeneous coordinates; 3 × 3 transformation matrices, **Elementary transforms** – translation, rotation, uniform & differential scaling, reflection, shear, Composite transforms; rotation about an arbitrary pivot, Window-to-viewport mapping; aspect-ratio preservation, 2-D clipping, **Line clipping** – Cohen-Sutherland, , Polygon clipping – Sutherland-Hodgman,

Section II

Unit 4: **3D Graphics & Projections**- (5 Hours)

3-D Cartesian & homogeneous coordinate systems; right-hand rule, 3-D object representations – polygon meshes, quad-meshes, boundary-rep, constructive solid geometry, parametric curves & surfaces (brief), **4 × 4 transformation matrices** – translation, rotation about coordinate & arbitrary axes, scaling, reflection, Composite 3-D transformations; Euler angles & gimbal lock, Introduction to **Parallel projections** – orthographic, axonometric (isometric, dimetric, trimetric), oblique,

Unit 5: **Illumination, Shading & Visible-Surface Algorithms**- (4 Hours)
Light–material interaction – ambient, diffuse (Lambert), specular (Phong), Shading methods – flat, Gouraud, Phong; normal interpolation, per-fragment shading, texture mapping overview, Shadow generation basics – shadow mapping, shadow volumes (idea only)

Unit 6: **Animation & Advanced Applications**- (4 Hours)
Principles of animation – key-framing, forward & inverse kinematics Motion capture pipeline, basics of skeletal animation Morphing techniques – linear blend-shape,

List of Experiments

1. **Pixel Plotting & Line Drawing**
   Implement DDA and Bresenham's line drawing algorithms. Compare outputs and discuss accuracy and efficiency.
2. **Circle and Ellipse Drawing**
   Implement midpoint algorithms for drawing circles and ellipses using integer arithmetic.
3. **Polygon Drawing and Filling**
   Draw arbitrary polygons and implement area-filling algorithms (boundary-fill and flood-fill).
4. **2D Transformations**
   Apply translation, rotation, scaling, and reflection to 2D objects using transformation matrices.
5. **Polygon Clipping**
   Implement Sutherland-Hodgman polygon clipping and Cohen-Sutherland line clipping algorithms.
6. **Viewport Transformation**
   Demonstrate window-to-viewport mapping with normalized coordinates.
7. **3D Transformations**
   Apply 3D transformations (translation, rotation, scaling) to basic models. **Use GenAI (eg. ShapeNet, DreamFusion) to generate the 3D model that can be transformed using learned techniques S**
8. **Projection Techniques**
   Implement orthographic and perspective projections for simple 3D objects.
9. **Lighting and Shading**
   Implement flat, Gouraud, and Phong shading models on 3D surfaces.

10. **Basic Animation and Object Export**
    Create a key-frame animation sequence and export a 3D object in OBJ format.

Textbook

1. **Donald Hearn & M. Pauline Baker**. *Computer Graphics with OpenGL*, **4th Edition**, Pearson, **2010**.
2. **Edward Angel & Dave Shreiner**. *Interactive Computer Graphics: A Top-Down Approach with WebGL*, **8th Edition**, Pearson, **2020**.
3. James D. Foley**, A. van Dam, John F. Hughes, et al.** *Computer Graphics: Principles and Practice*, **3rd Edition**, Addison-Wesley, **2019**.

Reference Books and E-Resources

1. **F. S. Hill Jr. & Stephen Kelley**. *Computer Graphics Using OpenGL*, **3rd Edition**, Prentice Hall, **2006**.
2. **David F. Rogers & J. Alan Adams**. *Mathematical Elements for Computer Graphics*, **2nd Edition**, McGraw-Hill, **1990**.
3. **Steve Marschner & Peter Shirley (eds.)**. *Fundamentals of Computer Graphics*, **5th Edition**, CRC Press, **2021**.
4. Steven Harrington**. *Computer Graphics: A Programming Approach, 2nd* Edition,** McGraw-Hill,

For MOOCs and other learning Resources

https://onlinecourses.nptel.ac.in/noc20_cs90/preview

Course Outcomes

Upon completion of the course, student will be able to –

1. Explain the architecture, hardware, and applications of computer graphics system
2. Implement raster algorithms for drawing primitives with color and antialiasing.
3. Apply 2D transformations and clipping using matrix operations.
4. Manipulate 3D models and projections for viewing and rendering.
5. Apply shading and visibility techniques to enhance realism.
6. Create simple animations and explore graphics file formats and shaders.

CO - PO Mapping:

Course Outcomes	Program Outcomes												PSO			
CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	2	0	0	1	1	1	0	0	1	0	1				
CO 2	3	3	3	1	2	0	0	0	0	1	0	1				
CO 3	3	3	3	1	2	0	0	0	0	1	0	1				
CO 4	3	3	3	1	3	0	1	0	0	1	0	1				
CO 5	3	2	3	1	3	0	1	0	0	1	0	1				
CO 6	3	2	3	2	3	0	0	0	0	2	0	2				
Average	3	2.5	2.5	1	2.3	0.16	0.5	0	0	1.17	0	1.17				

Multidisciplinary Minor

CHM001: NANO SCIENCE AND NANOTECHNOLOGY

Teaching Scheme:

Theory: 02 Hours / Week; Tut: 01 Hour / Week

Total Credits: 3

Syllabus

Theory

Unit 1: Introduction to Nanoscience and Nanotechnology

The nanoscale dimension and paradigm, definitions, history and current practice. Overview of current industry applications, Nanoscale science and engineering principles.

Unit 2: Introduction to Nanomaterials

Different types of nanomaterials: Metallic- Polymeric- Carbon- Metal Oxide- Core Shell. Physics of materials appropriate for applications to nanotechnology

Unit 3: Tools and techniques of Nanoscience and Nanotechnology

Spectral characterization: Absorption- Emission- Infra Red (IR) - Raman spectroscopy; X-ray diffraction; Structural characterization: - TEM- SEM; Surface characterization: STM- AFM.

Unit 4: Synthesis/ Fabrication of Nanomaterials

Methods of synthesis of nanomaterials Top-down approach, Bottom-up approaches, Bottom-up vs. top-down, Deposition Method, Colloidal Methods etc. Overview on nanomaterial synthesis- physical, chemical and biological methods.

Unit 5: Properties of Nanomaterials

Mechanical properties: Preparation for strength measurements, Mechanical properties, Magnetic properties, Electrical properties: electronic conduction with nanoparticles, Optical properties

Unit 6: Applications of nanomaterials

Current and potential applications of nanotechnology. Biological nanomaterials. Nanoelectronics. Nanomachines and nanodevices. Research directions. Economic, environmental and societal aspects of nanotechnology. Introduction to industries which produces commercial nanomaterials.

Syllabus

Tutorials

List of Tutorials

1. Comparison between particle analysis techniques
2. Basic calculations for nanoparticles
3. X-Ray Diffraction (XRD) Calculation
4. Nanoparticle Concentration from Colloidal Synthesis
5. Nanoparticle comparison for optical communications
6. Analysis of Nanoparticle for next generation energy storage
7. Nano photovoltaics for maximum efficiency of energy generation
8. Comparative study of different nanomaterials for 3D printing
9. Analysis of Nano adsorbents for contaminants remediation
10. Analysis of Density of States in Nanostructures
11. Design of carbon nanotube manufacturing plant
12. Cost Analysis of Nanomaterials

Course Outcomes

Student will be able to

1. Explain the concept of the nanoscale and identify key current applications and engineering principles of nanotechnology (3)
2. Explain various types of nanomaterials and their physical properties in relation to their suitability for nanotechnology applications (3)
3. Explain and apply various spectral, structural, and surface characterization techniques
4. Classify and describe various nanosynthesis methods (4)
5. Calculate different parameters and properties of nanoparticles (4)
6. Evaluate current and emerging applications of nanotechnology and assess the economic, environmental, and societal implications of nanotechnology (4)

Books and E-Resources

Text Books:

1. G.L., Hornyak, J., Dutta, H.F., Tibbals, A.K., Rao; 'Introduction to Nanoscience'; 1st Edition; CRC Press (Taylor and Francis Group LLC); 2008

2. M., Di Ventra, S., Evoy, J.R., Heflin Jr. (Eds.); 'Introduction to Nanoscale Science and Technologies'; 1st Edition; Springer; 2004

3. M., Rieth; 'Nano-Engineering in Science and Technology: An Introduction to the World of Nano Design'; 2nd Edition; World Scientific; 2009

Reference Books:

1. Z., Tang, P., Sheng; 'Nanoscience and Technology: Novel Structures and Phenomena'; 1st Edition; Taylor and Francis; 2003

2. R., Kelsall, I., Hamley, M., Geoghegan (Eds.); 'Nanoscale Science and Technology'; 1st Edition; Wiley; 2005

3. C.P., Poole Jr., F.J., Owens; 'Introduction to Nanotechnology'; 1st Edition; Wiley; 2003

4. S.A., Campbell; 'Fabrication Engineering at the Micro- and Nanoscale'; 4th Edition; Oxford University Press; 2012

5. M.H., Fan, C.P., Huang, A.E., Bland, Z.H., Wang, R., Sliman, I., Wright; 'Environanotechnology'; 2nd Edition; Elsevier; 2018

MOOCs and other learning Resources

1. Prof. N.M., Jokerst, **Prof. C., Donley**, **Prof. J., Cahoon**, **Prof. J., Jones**; 'Introduction to Nanotechnology'; Coursera; https://www.coursera.org/learn/nanotechnology; Accessed – May 1, 2025

Multidisciplinary Minor

CHM002: Biology and Engineering

Teaching Scheme:

Theory: …2 Hours / Week

Tutorial: …1 Hours / Week

Total Credits: 3

Syllabus

Theory

Unit 1: Biologically inspired technologies (4 Hours)

Nature inspired technologies, Biomemetics: Nature inspired material and mechanisms, Self-cleaning surfaces; Self-healing Bioconcrete, Biomining, Algorithms in nature

Unit 2: Impact of biotechnology (5 Hours)

Introduction to enzymes, enzyme technology and its applications in various sectors, Impact of biotechnology in agriculture, food, chemical, medicine and public health products, livestock breeding and animal health.

Unit 3: Biochemistry (5 Hours)

Introduction to structure of cells, important cell of types, growth of microbial cells. Bio-chemicals: Primary, secondary, tertiary structure of biomacromolecules such as lipids, sugars and polysaccharides, nucleotides, RNA, DNA, amino acids, proteins, hybrid biochemical etc interactions of these molecules

Unit 4: Analogy of biological organ/system and engineering Device/Mechanism (5 Hours)

Organ & system: Brain & CPU, Eye & Camera, Kidney & Filtration system, Lungs & purification system, Heart & Pumping system Process: Photosynthesis & solar cells, Thermoregulation in human body & heat transfer in machine, Défense mechanism in organism, signalling processing in biology and electronics

Unit 5: Concepts in Bioengineering (5 Hours)

Types, Properties and applications of biomaterials in engineering applications such as Biomechanics, Bioprinting, Biomaterials, Tissue Engineering

Unit 6: Applications of Bioengineering (4 Hours)

Various applications of Bioengineering in Databases & Biocomputing, Bioinstrumentation, Bio-medical imaging, Biosensors.

Syllabus

Tutorials

List of Tutorials

1. Study of applications of bioengineering in biomedical sector
2. Assignment based on biological inspired technologies
3. Study of applications of bioengineering in databases
4. Analysis of impact of biotechnology on various sectors
5. Study of different industrial important microorganisms
6. Study of different biochemicals
7. Study of enzyme technology
8. Study of recombinant DNA technology
9. Study of DNA modifications and mutations
10. Study of different biomaterials in engineering
11. Study of applications of bioengineering in computing
12. Study of applications of bioengineering in instrumentation

Course Outcomes

1. Students should be able to understand and describe biological inspired technologies
2. Students should be able to describe the impact of biotechnology on various sectors
3. Students should be able to describe different microorganisms and biochemicals

4. Students should be able to describe analogy of biological organ/system and engineering device/ mechanism
5. Students should be able to describe applications of biomaterials in engineering
6. Students should be able to describe applications of bioengineering in various sectors

Books and E-Resources

For Reference Print Book -

1. Baily J., Ollis D.; 'Biochemical Engineering'; 2nd Edition; McGraw Hill; 1986
2. Shuler M. L., Kaegi F.; 'Bioprocess Engineering – Basic Concepts' ; 2nd Edition; Prentice Hall Publication; 2002

For Reference Electronic Book –

3. Eggins B. R.; Chemical Sensors and Biosensore'; John Wiley & Sons Publishers, 2004. Accessed: May 22, 2025 [online]. Avaible: chrome-extension://kdpelmjpfafjppnhbloffcjpeomlnpah/https://download.e-bookshelf.de/download/0000/5741/24/L-G-0000574124-0002359078.pdf

For MOOCs and other learning Resources

1. Suraishkumar, Madhulika Dixit; 'Biology for engineers and non-biologist'; NPTEL; https://archive.nptel.ac.in/courses/121/106/121106008/ ; Accessed: May 22, 2025

Civil Engineering Department

Multidisciplinary Minor

CVM001: Climatology

Credits: 3

Teaching Scheme: Theory: 2 Hours /Week
Tutorial: 1 Hour/Week

Unit I - Atmospheric Structure and Climate (6 Hours)

Atmospheric structure and composition, Solar radiation and global energy budget, External and internal forcing, Climate feedback, Account of past climate, Environmental indicators and instrumental records

Unit II – Global Warming and Impact of Climate Change (6 Hours)

Human footprints on global warming, Predicting future climate, Temperature regimes, Extreme climate events Impact of climate change on agriculture, Impact of climate change on Livestock, Impact of climate change on biodiversity, Impact of climate change on water resources, Impact of climate change on livelihood, Impact of climate change on human health

Unit III– Climate Change and its mitigation (6 Hours)

Climate change vulnerability assessment, IPCC, Life Cycle Assessment, Geoinformatics in Climate Change Studies, Concept of mitigation and adaptation

Unit IV - International and national level initiatives on Climate Change (6 Hours)

Climate smart agriculture, Soil carbon sequestration, Biofuels, Climate Refugees, Climate Justice, Climate Change and Gender, International Initiatives, National Level Action Plan, State Level

Tutorials:

Two Assignments on each unit

Textbooks:

1. Global Warming and Climate Change by Agarwal S. K., First Edition, A P H Publishing Corporation, 2004
2. Foundations of Climatology by E.T. Stringer, Surjeet Publications, Delhi,1989
3. Impact of climate change on water resources Climate by Raju, K. Srinivasa, and D. Nagesh Kumar, 2018

Reference Books:

1. The rough guide to climate change by Robert Henson, London, New York, 2008. 2nd edition
2. Primer on Climate Change and Sustainable Development by Mohan Munasinghe and Rob Swart, Cambridge University Press, 2005
3. Barry RG and Chorley RJ. (2010). Atmosphere, weather and climate. 8th Edition. Routledge, New York. p.p.421
4. Burroughs WJ (2007) Climate Change: A multidisciplinary approach. 2nd Edition. Cambridge University Press. Pp.390. ISBN: 978-0-521-69033-1
5. Dessler A (2016) Introduction to Modern Climate Change. 2nd Edition. Cambridge University Press. ISBN: 978-521-17315-5

MOOCs Links and additional reading material:

1. https://www.ipcc.ch/assessment-report/ar5/
2. https://www.coursera.org/specializations/climatechangeandsustainableinvesting
3. https://moef.gov.in/moef/about-the-ministry/index.html

Course Outcomes:

At the end of the course the students will be able to:

1. Classify the Atmospheric Structure and Define the global energy budget, External and internal forcing
2. Explain the basic concepts of Human footprints on global warming, Predicting future climate, Temperature regimes and Extreme climate events
3. Explain the effect of Climate change on environment and its mitigation
4. Explain the importance of climate change at National and International Level

DEPARTMENT OF COMPUTER ENGINEERING
Multidisciplinary Minor

CSM001: Discrete Structures and Graph Theory

Credits: 3

Teaching Scheme Theory: 2 Hours/Week

Tutorial: 1 Hour/Week

Course Prerequisites: Basic understanding of school mathematics

Course Objectives:

1. To study basic discrete structures (such as functions, relations, sets, graphs, and trees)
2. To express mathematical properties via the formal language of propositional and predicate logic
3. To develop recurrence relations for a wide variety of combinatorial problems
4. To study advanced combinatorial techniques
5. To study elementary topics in number theory
6. To study elementary concepts in graph theory

Course Relevance: This is a foundational course for Computer Science and Engineering. The discrete structures play an essential role while modeling problems in computer science and engineering. The reasoning with different discrete structures is useful in understanding the underlying computer science problem more concretely. The course also builds problem solving ability.

Syllabus
Theory

Section 1: Topics/Contents

Unit 1: Logic and Proofs (4 Hours)

Propositional logic, propositional equivalences, truth tables, predicates and quantifiers, rules of inference, introduction to proofs: direct, contraposition, contradiction, counterexamples, principle of mathematical induction, strong induction. Proving the correctness of programs.

Unit 2: Elementary Discrete Structures and Basic Counting (5 Hours)

Elementary set theory (sets, set builder notation, cardinality, subsets, some finite and infinite sets, operations on sets), relations (relations and their properties, representing relations, closure of relations, equivalent relations), functions, partial orders, basic counting principles, permutations, combinations, generalized permutations and combinations (with / without repetitions, distinguishable/indistinguishable objects), Binomial coefficients and identities.

Unit 3: Advanced Combinatorial Techniques (5 Hours)
Double counting, combinatorial proof technique, Pigeon-Hole Principle, generalized pigeon-hole principle, some applications from: Ramsey theorem, Mantel's theorem, Turan's theorem, Erdos-Szekeres theorem.
Inclusion Exclusion Principle: Counting with Venn Diagrams, counting Derangements, number of primes up to n, number of onto functions, Euler's phi function.

Section 2: Topics/Contents

Unit 4: Recurrence relations and Generating Functions (5 Hours)
Recurrence relations, modelling using recurrence relations, some examples from: Fibonacci numbers, Catlan numbers, Derangements, Tower of Hanoi, partitions, solution of linear recurrence relations with constant coefficients (homogenous and non-homogenous), generating functions and their application in counting.

Unit 5: Modular Arithmetic (4 Hours)
Divisibility and modular arithmetic, Division Algorithm, primes, greatest common divisor, Euclid's Algorithm, extended Euclid's algorithm, modular inversion, Fundamental Theorem of Arithmetic, Congruence's, Fermat's little theorem, Euler's phi function, Chinese remainder theorem.

Unit 6: Graph Theory (5 Hours)
Graphs, different representations, properties of incidence and adjacency matrices, directed/undirected graphs, connected components, degree of a vertex, paths, cycles in graph, Euler and Hamiltonian tours/graphs, Trees, bipartite graphs (graph with only odd cycles, 2-colorable graphs), Planar graphs, Theorem bound on number of edges, Graph colorings, matching in bipartite graphs

Syllabus
Tutorials

List of Tutorials

1. Problem solving based on propositional logic
2. Problem solving based on basic set theory
3. Problem solving based on relations and functions
4. Problem solving based on basic counting principles
5. Problem solving based on properties of binomial coefficients
6. Problem solving based on permutations, combinations
7. Problem solving based on combinatorial proof technique
8. Problem solving based on double counting
9. Problem solving based on pigeon-hole principle
10. Problem solving based on inclusion exclusion principle
11. Problem solving based on modular arithmetic
12. Problem solving based on recurrence relations
13. Problem solving based on generating functions
14. Problem solving based on graphs and their properties

Course Outcomes

1. Reason mathematically about elementary discrete structures (such as functions, relations, sets, graphs, and trees) used in computer algorithms and systems
2. Express mathematical properties via the formal language of propositional and predicate logic
3. Develop recurrence relations with a wide variety of combinatorial problems
4. Demonstrate use of advanced combinatorial techniques
5. Describe elementary concepts in modular arithmetic and their applications
6. Exhibit understanding of basic graph theory and its applications

CO-PO Mapping

	Program Outcomes (PO)	PSO

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	3	1		1							2	2		
CO2	3	1				1			2		2	2	1	
CO3	3	2	3								2	2		
CO4	3	3	3	3							2	2		
CO5	3	3	1			1	2		1		2	2	1	
CO6	3	3	3	2		1		1			2	2	1	
Average	**3**	**2.3**	**1.6**	**1**	**0**	**0.5**	**0.3**	**0.1**	**0.5**		**2**	**2**	**0.5**	**0**

Future Courses Mapping: Data structures, Design and analysis of algorithms, theory of computation, artificial intelligence, machine learning.

Job Mapping:

Wherever one wants to model a computer science problem concretely the use of discrete structures is essential. Due to the abstract nature of the course, the principles learnt have wide applicability. In any job which requires algorithmic thinking, programming, use of data structures, the knowledge of discrete structures is very helpful.

Textbooks:

1. *"Discrete Mathematics and its applications" by Kenneth Rosen (William C Brown Publisher)*
2. *"Applied Combinatorics" by Alan Tucker (Wiley Publishing company)*
3. *"Combinatorics: Topics, techniques, algorithms" by Peter J. Cameron (Cambridge University Press)*
4. *Graph Theory by Reinhard Diestel (Springer Verlag Publishing Company)*
5. *Introduction to Graph Theory by Douglas B. West (Prentice-Hall publishers)*

Multidisciplinary Minor

CIM001: Discrete Mathematics

Course Prerequisites:

1.Basic knowledge of mathematics and logic

Course Objectives:

1.To provide strong basic discrete structures in mathematical reasoning and logic essential for computer science problem-solving and theoretical computation.

2.To develop recurrence relations for a wide variety of combinatorial problems and counting.

3.To develop a comprehensive understanding of fundamental algebraic structures including groups, rings, and fields.

4.To understand and apply solid foundation in the principles and techniques of number theory.

5.To familiarize students' fundamental concepts and structures in graph theory and develop analytical skills for modelling and solving real-world problems using graphs.

6.To understand the theory and application of tree structures in graph theory.

Course Relevance: This is a foundational course for Computer Science and Engineering. The discrete structures play an essential role while modelling problems in computer science and engineering. The reasoning with different discrete structures is useful in understanding the underlying computer science problem more concretely. The course also builds problem solving ability.

Syllabus

Theory

Section 1: Topics/Contents

Unit 1: Set Theory and Logic (4 Hours)

Sets: Sets and Subsets, Power Set, Cartesian Product, Set Operations, Venn Diagram, Inclusion-Exclusion Principle, Computer Representation of Sets. **Relations:** Product Sets, Pictorial Representatives of Relations, Composition of Relations, Types of Relations, Closure Properties, Equivalence Relations, Partial Orderings, partitions, Hasse Diagram, Lattices. **Logic:** Propositions, Truth Tables, Tautologies, Conditional Propositions and Logical Equivalence, Arguments and Rules of Inference. **Functions:** Domain, range, One-to-One, Onto, and Invertible Functions, Exponential and Logarithmic Functions, Cardinality, Algorithms and Functions

Unit 2: Recursion and Counting Methods (5 Hours)

Mathematical Induction, Recursion, Recurrence Relation, Solving Recurrence Relations, The Basics of Counting, rule of Sum and Product, Permutations and Combinations, Binomial Coefficients and Identities, Algorithms for generating Permutations and Combinations, The Principle of Inclusion-Exclusion, The Addition and Multiplication Rules, The Pigeon-Hole Principle.

Unit 3: Algebraic Structures (5 Hours)

The structure of algebra, Algebraic Systems, Semi-Groups, Monoids, Groups, Subgroups and Their Properties -Cyclic Groups - Cosets - Permutation Groups - Lagrange's Theorem - Cayley's Theorem -Normal Subgroups - Homomorphism Of Groups - Quotient Groups –Introduction to Rings and Fields.

Section 2: Topics/Contents

Unit 4: Number Theory (5 Hours)

Number theory overview, Divisors - Properties of Divisibility, Division Algorithm, Greatest Common Divisor GCD and its Properties, Remainder Classes, Properties of Congruence, Solving Congruences, Euclidean Algorithm, Extended Euclidean Algorithm, Prime Factorization Theorem, Modular Arithmetic, Euler Phi Function, Euler's Theorem, Fermat's Little Theorem, Additive and Multiplicative Inverses, Chinese Remainder Theorem.

Unit 5: Graph Theory (5 Hours)

Graphs and Simple Graphs, Paths and Cycles, The Incidence and Adjacency Matrices, Vertex Degrees, Paths and Connection, Cycles, Hamiltonian Cycles, Subgraphs - Graph Isomorphism, Directed and Undirected graphs, Vertex types - Isolated and pendent vertices, In degree and out degree, The handshaking theorem, Types of graphs – Null graph, regular graph, complete graph, Operations of graphs – Union, Intersection, Sum of two graphs, Product of graphs, Composition, complement, Vertex And Edge Cuts - Vertex And Edge Connectivity.

Unit 6: Trees (5 Hours)

Trees - Acyclic graph, Terminology and Characterizations of Trees, Forest, Spanning tree, Minimal Spanning, Branch of tree, Chord, Rooted tree, Co tree, Binary tree - Path length of a binary tree, Binary tree representation of general trees, Counting trees, Tree traversal - Preorder traversal, Post order traversal, In order traversal, Complete binary tree - Almost complete binary tree, Representation of algebraic structure of binary trees, Infix, prefix and postfix notation of an arithmetic expression - Infix notation, Prefix notation, Postfix notation, Evaluating prefix and postfix form of an expression, Shortest path algorithms - Dijkstra's algorithm, Minimal spanning trees - Weighted graph, Minimal spanning tree, Algorithm for minimal spanning tree - Kruskal's algorithm, Prim's algorithm.

Syllabus
Tutorials

List of Tutorials

1. Problem solving based on propositional logic
2. Problem solving based on basic set theory
3. Problem solving based on relations and functions
4. Problem solving based on basic counting principles
5. Problem solving based on properties of binomial coefficients
6. Problem solving based on permutations, combinations
7. Problem solving based on combinatorial proof technique
8. Problem solving based on double counting
9. Problem solving based on Euler's and Fermat's theorems in calculations.
10. Problem solving based on Number Theory Theorems

11. Problem solving based on Paths, Cycles, and Connectivity
12. Problem solving based on Graph Theorems and Applications
13. Problem solving based on Tree Traversals
14. Problem solving based on Spanning Trees

Course Outcomes

1. Reason mathematically about elementary discrete structures (such as functions, relations, sets, graphs, and trees) used in computer algorithms and systems
2. Express mathematical properties via the formal language of propositional and predicate logic
3. Develop recurrence relations for a wide variety of combinatorial problems
4. Demonstrate use of advanced combinatorial techniques
5. Describe elementary concepts in modular arithmetic and their applications
6. Exhibit understanding of basic graph theory, tree and its applications

CO-PO Mapping

	Program Outcomes (PO)											PSO		
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1		1							2	2		
CO2	3	1				1			2		2	2	1	
CO3	3	2	3								2	2		
CO4	3	3	3	3							2	2		
CO5	3	3	1			1	2		1		2	2	1	
CO6	3	3	3	2		1		1			2	2	1	
Average	**3**	**2.3**	**1.6**	**1**	**0**	**0.5**	**0.3**	**0.1**	**0.5**		**2**	**2**	**0.5**	**0**

Future Courses Mapping: Data structures, Design and analysis of algorithms, theory of computation, artificial intelligence, machine learning.

Job Mapping:

Wherever one wants to model a computer science problem concretely the use of discrete structures is essential. Due to abstract nature of the course, the principles learnt have wide applicability. In any job which requires algorithmic thinking, programming, use of data structures, the knowledge of discrete structures is very helpful.

Textbooks:

1. *"Discrete Mathematics and its applications" by Kenneth Rosen (William C Brown Publisher)*
2. *C. L. Liu and D. P. Mohapatra, "Elements of Discrete Mathematics", 4th Edition, McGraw-Hill.*
3. *"Applied Combinatorics" by Alan Tucker (Wiley Publishing company)*
4. *"Combinatorics: Topics, techniques, algorithms" by Peter J. Cameron (Cambridge University Press)*
5. *Graph Theory by Reinhard Diestel (Springer Verlag Publishing Company)*
6. *Introduction to Graph Theory by Douglas B. West (Prentice-Hall publishers)*

Multidisciplinary Minor

MLM001: Discrete Mathematics

Teaching Scheme:

Theory: 2 Hours / Week.

Tutorial: 1 Hours / Week.

Total Credits: 2

Course Prerequisites:

Basic Mathematics

Course Objectives:

1. **To understand fundamental concepts of discrete mathematics, including functions, relations, sets, graphs, and trees.**
2. **To apply mathematical properties using the formal language of propositional and predicate logic.**
3. **To construct recurrence relations to model and solve various combinatorial problems.**
4. **To apply advanced combinatorial techniques to solve complex counting problems.**
5. **To analyse basic number theory topics and their applications in discrete structures.**
6. **To analyse foundational graph theory and tree concepts and their role in modelling discrete systems.**

Course Relevance: Discrete Mathematics is a fundamental course that plays a critical role in computer science, engineering, and mathematics. It provides the essential theoretical foundation for understanding key concepts such as logic, set theory, combinatorics, graph theory, and algorithms. These concepts are directly applied in fields like software development, cryptography, database systems, and network design. The course also sharpens logical

reasoning and problem-solving skills, which are vital for designing efficient algorithms and writing accurate programs. Additionally, discrete mathematics supports advanced topics in artificial intelligence, machine learning, and cybersecurity. Its emphasis on precise thinking and formal proof techniques makes it a crucial subject for academic research, technical careers, and competitive exams in the STEM fields.

Syllabus

Theory

Section 1: Topics/Contents

Unit 1: Set Theory and Logic (5 hrs.)

Introduction and significance of Discrete Mathematics, Sets– Naïve Set Theory (Cantorian Set Theory), Axiomatic Set Theory, Set Operations, Cardinality of set, Principle of inclusion and exclusion. Types of Sets – Bounded and Unbounded Sets, Diagonalization Argument, Countable and Uncountable Sets, Finite and Infinite Sets, Countably Infinite and Uncountably Infinite Sets, Power set, Propositional Logic- logic, Propositional Equivalences, truth tables, Application of Propositional Logic Translating English Sentences, predicates and quantifiers, rules of inference, introduction to proofs: direct, contraposition, contradiction, counterexamples, principle of mathematical induction, strong induction, proving the correctness of programs

Unit 2: Relations and Functions (4 hrs.)

Relations and their Properties, n-ary relations and their applications, Representing relations, Closures of relations, Equivalence relations, Partial orderings, Partitions, Hasse diagram, Lattices, Chains and Anti-Chains, Transitive closure and Warshall's algorithm. Functions- Surjective, Injective and Bijective functions, Identity function, Partial function, Invertible function, Constant function, Inverse functions and Compositions of functions, The Pigeonhole Principle.

Unit 3: Counting principles (5 hrs.)

The Basics of Counting, rule of Sum and Product, Permutations and Combinations, Binomial Coefficients and Identities, Generalized Permutations and Combinations, Algorithms for generating Permutations and Combinations, Double counting, Pigeon-Hole Principle, generalized pigeon-hole principle, Some applications from: Ramsey theorem, Mantel's theorem, Turan's theorem, Erdos-Szekeres theorem, Inclusion Exclusion Principle: Counting with Venn Diagrams, counting Derangements, number of primes up to n, number of onto functions, Euler's phi function.

Section 2: Topics/Contents

Unit 4: Modular Arithmetic (4 hrs.)

Divisibility and modular arithmetic, Division Algorithm, primes, greatest common divisor, Euclid's Algorithm, extended Euclid's algorithm, modular inversion, Fundamental Theorem of Arithmetic, Congruence's, Fermat's little theorem, Euler's phi function, Chinese remainder theorem.

Unit 5: Graph Theory (5 hrs.)

Introduction to Graphs, different representations, properties of incidence and adjacency matrices, directed/undirected graphs, connected components, degree of a vertex, paths, cycles in graph, Euler and Hamiltonian tours/graphs, the handshaking lemma, Single source shortest path Dijkstra's Algorithm, Planar Graphs, Graph Colouring, Trees, bipartite graphs (graph with only odd cycles, 2-colorable graphs), Planar graphs, Theorem on bound on number of edges.

Unit 6: Trees (5 hrs.)

Introduction to trees, properties of trees, Binary search tree, tree traversal, decision tree, prefix codes and Huffman coding, cut sets, Spanning Trees and Minimum Spanning Tree, Kruskal's and Prim's algorithms, The Max flow- Min Cut Theorem (Transport network).

Tutorials

List of Tutorials

1. **Solving problems involving basic set theory**
2. **Solving problems using propositional logic**
3. **Solving problems related to relations and functions**
4. **Solving problems using fundamental counting principles**
5. **Solving problems involving binomial coefficient properties**
6. **Solving problems on permutations and combinations**
7. **Solving problems using combinatorial proof techniques**
8. **Solving problems through double counting methods**
9. **Solving problems based on the pigeonhole principle**
10. **Solving problems using the inclusion-exclusion principle**
11. **Solving problems involving modular arithmetic**
12. **Solving problems using recurrence relations**
13. **Solving problems with generating functions**
14. **Solving problems involving graphs and their characteristics**

Course Outcomes

The students will be able to:

1. **Apply fundamental concepts of discrete mathematics—such as functions, relations, sets, graphs, and trees—to reason about computer algorithms and systems.**
2. **Formulate mathematical properties using the formal language of propositional and predicate logic.**
3. **Construct recurrence relations to model and solve various combinatorial problems.**
4. **Apply advanced combinatorial techniques to analyse and solve complex counting problems.**
5. **Explain basic principles of modular arithmetic and illustrate their applications in computing.**
6. **Demonstrate an understanding of essential graph theory concepts and their real-world applications.**

CO-PO Mapping

	Program Outcomes (PO)											PSO		
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2		2							2	2		
CO2	3	2				1			2		2	2	1	
CO3	3	2	3								2	2		
CO4	3	3	3	3							2	2		
CO5	3	3	1			1	2		1		2	2	1	
CO6	3	3	3	2		1		1			2	2	1	
Average	3	2.5	1.6	1.16	0	0.5	0.3	0.1	0.5		2	2	0.5	0

Future Courses Mapping: Data structures, Design and analysis of algorithms, Theory of Computation, Compiler Design, Artificial Intelligence, Machine Learning.

Job Mapping:

Wherever one wants to model a computer science problem concretely the use of discrete structures is essential. Due to the abstract nature of the course, the principles learnt have wide applicability. In any job which requires algorithmic thinking, programming, use of data structures, the knowledge of discrete structures is very helpful.

Textbooks:

1. ***"Discrete Mathematics and its applications" by Kenneth Rosen (William C Brown Publisher)***
2. ***"Applied Combinatorics" by Alan Tucker (Wiley Publishing company)***

3. *"Combinatorics: Topics, techniques, algorithms" by Peter J. Cameron (Cambridge University Press)*
4. *Graph Theory by Reinhard Diestel (Springer Verlag Publishing Company)*
5. *Introduction to Graph Theory by Douglas B. West (Prentice-Hall publishers)*

Multidisciplinary Minor

DSM001: DATA VISUALIZATION

Teaching Scheme:

Theory: 2 Hours / Week.

Tutorial: 1 Hour / Week.

Total Credits: 3

Syllabus

Theory

Unit I: Introduction to Data Visualization (6 Hrs)

Importance of data visualization, Data-to-visualization pipeline, Types of data: categorical, numerical, temporal, spatial, Data graphics principles (Tufte, Few, etc.) Perception and cognitive aspects in visualization, Case studies and examples.

Unit II: Charts and Graphs for Different Data Types (6 Hrs)

Bar charts, pie charts, histograms, line plots, area charts, Scatter plots, bubble charts, box plots, Time series, hierarchical (tree maps, sunbursts), network and spatial visualizations, Dos and Don'ts of chart selection, Choosing the right chart for the story.

Unit III: Tools, Frameworks & Coding for Visualization (6 Hrs)

Spreadsheet tools (Excel, Google Sheets), Python libraries: Matplotlib, Seaborn, Plotly, Tableau: Basic layout, measures and dimensions, integrating charts with dashboards, Exporting and sharing visualizations.

Unit IV: Interactive Dashboards and Storytelling with Visuals (6 Hrs)

Designing and building dashboards (Tableau, Power BI, Streamlit basics), Interactive elements (filters, tooltips, drill-downs), Visual storytelling structuring narratives, Case studies – business, healthcare, and academic datasets, Evaluation of visualization impact.

Tutorials

List of Assignments

1. Understand how to visualize a dataset using various chart types and derive insights.
2. Learn how to create a small dashboard using interactive visual elements.
3. Learn how different Python visualization libraries function.
4. Design a dashboard that tells a compelling story.
5. Explore how GenAI can assist in automating dashboard generation.
6. End-to-end use of GenAI to build and narrate a data-driven story.
7. Compare patterns and trends between two different geographical areas.
8. Analyse and visualize how data changes over time.
9. Transform raw data into a visually appealing infographic.
10. Use AI tools to auto-generate insights and validate them manually.

Course Outcomes

1. Explore the fundamentals of data visualization and its role in data-driven decision making.
2. Select and design appropriate charts for various types of datasets.
3. Implement data visualizations using tools and programming frameworks.
4. Develop interactive dashboards and communicate data stories effectively.
5. Analyse case studies to evaluate the impact of different visualization approaches.

Books and E-Resources

For Reference Print Book -

1. K. Wexler, J. Shaffer, A. Cotgreave; *The Big Book of Dashboards: Visualizing Your Data Using Real-World Business Scenarios*; 1st Edition; Wiley; 2017; ISBN-13: 978-1-119-28271-6

For Reference Electronic Book –

1. Sharda, R., Delen, D., Turban, E.; *Business Intelligence, Analytics, and Data Science: A Managerial Perspective*; 5th Edition; Pearson; 2023; ISBN-13: 9780137931286

2. P. M. Joshi, P. N. Mahalle; *Data Storytelling and Visualization with Tableau: A Hands-On Approach*; 1st Edition; CRC Press; 2022; ISBN-13: 978-1-0323-10935-0; eBook ISBN-13: 978-1-0006-8672-2

For MOOCs and other learning Resources

1. J. Heer; 'Data Visualization'; Coursera – University of Washington https://www.coursera.org/learn/datavisualization

2. J. Brooks; 'Data Visualization with Python'; IBM via Coursera https://www.coursera.org/learn/python-for-data-visualization

3. K. Vohra; 'Data Visualization with Tableau'; University of California, Davis via Coursera https://www.coursera.org/learn/data-visualization-tableau

Multidisciplinary Minor

CIM001: Internet of Things

Teaching Scheme:
Theory: 2 Hours / Week: Laboratory: 2 Hours / Week
Total Credits: 3

Syllabus

Theory

Unit I: Introduction to IoT (6 Hrs.)

Introduction, Definitions & Characteristics of IoT, History of IoT, IoT Architectures, Physical & Logical Design of IoT, Enabling Technologies in IoT, About Things in IoT, The Identifiers in IoT, About the Internet in IoT, IoT frameworks, IoT and M2M.

Unit II: Introduction of Microprocessor & Microcontroller (6 Hrs.)

Basics of Microprocessor, Types & evolution, Block diagram & functioning, Evolution of microcontrollers, Microcontroller selection criteria for particular application, MCS-51 architecture, family devices & its derivatives. Pin configuration, Port architecture, memory organization, external memory interfacing.

Unit III: IP based Protocols for IOT (6 Hrs.)

IPv6, 6LowPAN, RPL, REST, AMPQ, CoAP, MQTT.
Authorization and Access Control in IOT

Unit IV: IoT Security and Privacy (6 Hrs.)

Challenges and threats to IoT security, Encryption and authentication techniques, Privacy concerns and regulations, best practices for securing IoT devices

Syllabus

Laboratory

List of Experiments

1. Study & Survey of various development boards for IoT.
2. Study & Survey of various IoT platforms.
3. Interfacing sensors and actuators with Arduino Uno
4. Build a cloud-ready temperature sensor with the Arduino Uno and any IoT Platform

5. Interfacing Sensors and actuators with Arduino Uno
6. IoT based Stepper Motor Control with Raspberry Pi.
7. IoT based Web Controlled Home Automation using Arduino Uno
8. A Simple IoT Project with the ESP8266 Wi-Fi module
9. Implement a RFID Based IoT Project

Course Outcomes

After completion of the course, students will be able to:

- CO1. Explain the various concepts, terminologies, and architecture of IoT systems.
- CO2. Understand the working of microprocessor & Microcontroller.
- CO3. Explore and apply various protocols for the design of IoT systems.
- CO4. Gain knowledge of IoT Security and Privacy methods.

Books and E-Resources

Reference Print Book

- Hakima Chaouchi, "The Internet of Things Connecting Objects to the Web" ISBN: 978-1- 84821-140-7, Wiley Publications
- Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", WileyPublications
- Internet of Things, Arsheep Bahga and Vijay Madisetti.
- Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications

Reference Electronic Book

https://mrcet.com/downloads/digital_notes/EEE/IoT%20&%20Applications%20Digital%20Notes.pdf

MOOCs and other Learning Resources

1. Arduino Project Hub; TinyML Projects with Arduino; Arduino.cc; https://create.arduino.cc/projecthub; Accessed: May 12, 2025
2. Coursera
3. Udemy

Multidisciplinary Minor

SEM001: Agile Principles and Methodology

Credits: 3
Teaching Scheme: Theory: 2 Hours/Week, Tut: 1 Hours/Week

Prerequisites

Basics of Software Engineering

Course Objectives

- To introduce characteristics of an agile development process.
- To understand agile software development process models and plan driven process models.
- To understand software project characteristics that would be suitable for an agile process.
- To impart and Identify software project characteristics that would not be suitable for an agile process.

Unit I: FUNDAMENTALS OF AGILE (6 Hours)

The Genesis of Agile, Introduction and background, Agile Manifesto and Principles, Overview of Scrum, Extreme Programming, Feature Driven development, Lean Software Development, Agile project management, Design and development practices in Agile projects, Test Driven Development, Continuous Integration, Refactoring, Pair Programming, Simple Design, User Stories, Agile Testing, Agile Tools

Unit II: AGILE SCRUM FRAMEWORK (6 Hours)

Introduction to Scrum, Project phases, Agile Estimation, Planning Game, Product backlog, Sprint backlog, Iteration planning, User story definition, Characteristics and content of user stories, Acceptance tests and Verifying stories, Project velocity, Burn down chart, Sprint planning and retrospective, Daily scrum, Scrum roles Product Owner, Scrum Master, Scrum Team, Scrum case study, Tools for Agile project management.

Unit III: AGILE TESTING (6 Hours)

The Agile lifecycle and its impact on testing, Test-Driven Development (TDD), Unit framework and tools for TDD, testing user stories - acceptance tests and scenarios, Planning and managing testing cycle, Exploratory testing, Risk based testing, Regression tests, Test Automation, Tools to support the Agile tester.

Unit IV: AGILE SOFTWARE DESIGN AND DEVELOPMENT (6 Hours)

Agile design practices, Role of design Principles including Single Responsibility Principle, Open Closed Principle, Liskov Substitution Principle, Interface Segregation Principles, Dependency Inversion Principle in Agile Design, Need and significance of Refactoring, Refactoring Techniques, Continuous Integration, Automated build tools.

Tutorials / Assignments

1. Study & evaluate the historical and contextual factors that contributed to the rise of Agile software development methodologies.
2. Create & evaluate the definition of user stories and explain their significance within the context of Agile software development methodologies.
3. Create a Scrum Team which defines & identifies the key roles within a Scrum Team based on Real Time Scenario.
4. Apply Design principle and Refactoring to achieve agility based on the above Real Time Scenario.
5. Implement Jira, a project management tool that helps teams plan, track, and manage work for Software Application.
6. Case study (Agile in Software Development vs. Other Industries (Manufacturing, Education, Healthcare)
7. Study and implement automated build tool Docker/ Kubernetes/ OpenShift for an Application.
8. Use Continuous Integration tool such as Jenkins for Software Implementation.
9. Perform Testing activities within an agile project using Jira.

Course Outcomes

At the end of the course the student should be able to:

CO1: Explain fundamentals of Agile methodology.

CO2: Explain agile principles.

CO3: Apply Scrum principles.

CO4: Apply practices of XP and Incremental design.

Textbooks & References

Textbooks:

1. Agile Development with Scrum, Ken Schwaber & Mike Beedle, Prentice Hall

2. Integrating Agile Development in the Real World, Peter Schuh, Charles River Media

Reference Books:

1. Agile Software Development – The Cooperative Game (2nd Edition), Alistair Cockburn.

2. Succeeding With Agile, Software Development Using Scrum, Mike Cohn, Addison Wesley

Multidisciplinary Minor

ETM001: IOT for Smart Applications

Total Credits: 3

Teaching Scheme:
Theory: 2 Hours / Week;
Tutorial: 1 Hours / Week

SECTION I:

UNIT I: Introduction to IoT (4 hrs)

Introduction, Definitions Characteristics of IoT, History of IoT, IoT Architectures, Physical Logical Design of IoT, Enabling Technologies in IoT, About Things in IoT, The Identifiers in IoT, About the Internet in IoT, IoT frameworks, IoT and M2M

IoT in different engineering domains: Civil, Mechanical, Electrical, Biomedical, Agriculture, Transport. Introduction to microcontrollers:

UNIT II:IOT Design Methodology and Platform (4 hrs)

IoT Design Methodology Steps and IoT System Design Cycle.

Hardware Platforms - Arduino, Raspberry Pi, NodeMCU, ESP32, Introduction to RTOS in IoT. Sensor, actuators selection criteria for specific applications and interfacing basics.

UNIT III:IOT Protocols and Standards (6 hrs)

RFID, IEEE 802.15.4, Zigbee, HART, NFC, Z-Wave, BLE, Bacnet, Modbus.

IPv6, 6LowPAN, RPL, REST, AMPQ, CoAP, MQTT. Authorization and Access Control in IOT.

SECTION II:

UNIT IV: Wireless Sensor Networks for IOT (4 hrs)

Types of Wireless Sensors, Examples and Working, Wireless Sensor Networks: History and Context, of the node, Connecting nodes, Networking Nodes, WSN and IoT. Types of Network and network topologies for IOT.

UNIT V: Cloud Integration and Data Visualization (5 hrs)

Cloud platforms for IoT: Thing Speak, Blynk, Firebase. Real-time data logging, charting, and alerts. Actuation using relays and triggers based on sensor data. Security and privacy fundamentals: Security Challenges in IoT Systems, Authentication, Authorization, and Access Control, Data Encryption and Secure Communication Protocols.

UNIT VI: Domain-Specific Smart Systems: Case Studies (4 hrs)

Designing IoT Applications: Requirement Analysis and Architecture, Development of a Sample IoT Application, Integration with Cloud Services and APIs

Case studies: Smart agriculture, Smart health, Smart cities, Smart transportation, Industrial IoT. System integration and real-world challenges. Mini project planning, development, and presentation

List of Experiments

1. Study & Survey of various development boards, sensors for IoT and various IoT platforms
2. Implementation of basic programs on Arduino UNO /NANO board using Arduino platform/Tinker cad platform to interface LED, OLED, LCD with optimization of hardware in terms of GPIO ports.
3. Implementation of basic programs on Arduino UNO /NANO board using Arduino platform/Tinker cad platform to interface various sensors and actuators.
4. Interfacing Wi-Fi ESP8266/ESP01 module with Arduino UNO/NANO and its Programming for interfacing of actuators and controlling using Blynk IOT Cloud platform.
5. To build an ESP8266 NodeMCU Based web server
6. To setup and use ESP32 Cam with Micro USB Wi-Fi Camera
7. Introduction of Raspberry Pi, OS installation on Raspberry Pi and sample python programming for LED / DHT11 / Stepper Motor Control interfacing.
8. Interfacing of DHT11 sensor with Raspberry Pi to monitor temperature and humidity by using Thing-speak Cloud.
9. IoT based Web Controlled Home Automation using Raspberry Pi.
10. A Simple IoT Project with the ESP8266 WiFi module: Here is a simple project with ESP8266 wi-fi module. This project collects the temperature and is displayed on the network

Suggested Sensors for project to respective domain:

Domain	Suggested Sensors
Civil	Ultrasonic, MQ135, Soil Moisture, Vibration
Mechanical	Load Cell, Thermocouple, Accelerometer
Electrical	Voltage/Current Sensors, LDR, Relay
Biomedical	Pulse Sensor, MLX90614, MAX30100
Agriculture	Soil Moisture, DHT11, UV Sensor, pH Sensor
Transport	GPS, IR, Hall Sensor, Accelerometer

List of Project areas:

1. Smart Home & Building Automation.
2. Smart Agriculture.
3. Smart Healthcare & Biomedical
4. Smart Transportation & Mobility
5. Industrial IoT & Predictive Maintenance
6. Civil and Infrastructure Monitoring
7. Electrical & Energy Systems
8. Environmental Monitoring

Course Outcomes

The student will be able to –

1. CO1: Demonstrate fundamental concepts of Internet of Things (L3 – Apply)
2. CO2: Recognize IoT Design Methodology Steps (L2-Understand)
3. CO3: Apply basic Protocols in IoT (L3 – Apply)
4. CO4: Analyse fundamentals of networking (L4-Analyze)
5. CO5: Apply of cloud platforms to visualize real-time sensor data (L3 – Apply)
6. CO6: Provide IoT solutions practically with the help of case study (L6 – Create)

Books and E-Resources

For Reference Print Book -

1. R. Kamal, Internet of Things: Architecture and Design Principles, 1st ed., McGraw Hill Education, 2021.
2. Olivier Hersent, D. Boswarthick, and O. Elloumi, The Internet of Things: Key Applications and Protocols, 2nd ed., Wiley, 2021.
3. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press

Textbooks:

1. ArsheepBahga and Vijay Madisetti, Internet of Things: A Hands-On Approach, 1st ed., Universities Press, 2014.
2. Adrian Mcewen and Hakim Cassimally, Designing the Internet of Things, 1st ed., Wiley, 2013.
3. Daniel Lion, Introduction to Internet of Things (IoT), 1st ed., Independently Published, 2023.
4. S. Verma, R. Verma, O. Farhaoui, and J. Lyu, Eds., Emerging Real-World Applications of Internet of Things, 1st ed., CRC Press, 2024.

For MOOCs and other learning Resources

1. https://www.coursera.org/specializations/iot, **An Introduction to Programming the Internet of Things (IOT) Specialization.** Create Your Own Internet of Things (IoT) Device. Design and create a simple IoT device in just six courses. Instructor: Ian Harris
2. https://www.coursera.org/learn/raspberry-pi-interface Interfacing with the Raspberry Pi, This course is part of An Introduction to Programming the Internet of Things (IOT) Specialization. Instructor: Ian Harris

Bansilal Ramnath Agarwal Charitable Trust's

VISHWAKARMA INSTITUTE OF TECHNOLOGY, PUNE – 37

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

Multidisciplinary Minor

ETM002: Microcontroller and Applications

Total Credits: 3

Teaching Scheme:

Theory: 2 Hours / Week

Tutorial: 1 Hours / Week

UNIT 1: Introduction to Microcontrollers and Architecture (5)

Microprocessor & Microcontroller comparison, Harvard & Von Neumann architecture, RISC & CISC comparison, Evolution of microcontrollers, Microcontroller selection criteria for particular application, MCS-51 architecture, family devices & its derivatives. Pin configuration,

UNIT 2: Internal modules of 8051 microcontroller (4)

Internal Port architecture, memory organization, external memory interfacing. Timers and its modes. Interrupt structure, Serial communication and its modes.

UNIT 3: 8051 Instruction Set, Programming and development tools (5)

Addressing modes, 8051 Instruction set, Programming environment: Study of software development tool chain (IDE), debugging tools, Programs: Assembly language programs.

SECTION II:

UNIT 4: 8051 Microcontroller based Real World Interfacing and programming I (5)

Interfacing peripheral devices using GPIO: LEDs 7 segment LED, generating various delays using timer, counter, switches, relay, stepper motor, LCD interfacing, keyboard interfacing, (Programming in C).

UNIT 5: 8051 Microcontroller based real world interfacing and programming II (4)

Basics of serial communication protocol: Synchronous and asynchronous communication, RS232, RS485, SPI, I2C. Interfacing of devices using protocols: Interfacing of peripherals using UART, interfacing RTC DS1307 using I2C protocol, Programs in C.

UNIT 6: AVR RISC Microcontroller and programming (5)

Overview of AVR family, AVR Microcontroller architecture, ROM space and other hardware modules, **interfacing peripheral devices with AVR:** DC motor control using PWM programming, ADC and temperature sensor LM35 interfacing, **Application areas:** home automation, smart health, smart agriculture. Design of simple real-life applications using microcontroller platforms

Laboratory

List of Experiments

List of Practical :

1. Simple programs to explore 8051 IDE (Addition, subtraction, multiplication etc)
2. Interfacing of LED's, switches, buzzer, relay with 8051 Microcontroller.
3. Interfacing of 16x2 LCD in 8 bit/4-bit mode with 8051 Microcontroller and display message on it.
4. Interface 4x4 matrix keyboard with 8051 Microcontroller. Display value of pressed switch on LCD.
5. Interface Computer with 8051 Microcontroller using UART communication.
6. Interface stepper Motor with 8051Microcontroller and write program to rotate it in clockwise and anticlockwise direction using different drives (Full step drive, Half step drive and wave drive).
7. Interfacing of ADC PCF8591 with 8051 Microcontroller using IIC protocol read the analog voltage from ADC and display its equivalent digital value on LCD.
8. AVR based Temperature indicator using sensor LM35
9. Servo Motor interfacing with AVR ATMega32 Microcontroller
10. DC Motor interfacing with AVR ATMega32 Microcontroller
11. Colour object sorting system using AVR

III. SCE: Project Based Learning Mini Project/Seminar (SCE)

Implementation of hardware and software for specific application using 8051/AVR

List of Project areas:

1. Home Automation
2. Security Systems
3. Automotive Applications

4. Industrial Automation
5. Timing and Counting Systems
6. Measurement and Monitoring

Course Outcomes

The student will be able to –

1. Explain the architecture of 8051 CISC and RISC microcontroller. (Level 2 Understand)
2. Understand the internal peripheral modules in 8051 microcontroller. (Level 2 Understand)
3. Write and debug assembly language programs using appropriate instruction sets, addressing modes, and debugging tools. (Level 3 Apply)
4. Interface peripheral devices with the 8051 microcontroller. (Level 3 Apply)
5. Demonstrate bus standards used in industrial environment. (Level 3 Apply)
6. Develop system using different microcontroller based for embedded applications. (Level 6 Create)

Books and E-Resources

For Reference Print Book -

1. Dhananjay Gadre, Programming and Customizing the AVR Microcontroller, McGraw Hill edu.
2. Richard Barnett, Sarah Cox, Larry O'Cull, "Embedded C Programming and the AVR Microcontrollers", 2nd edition Thomson publication.
3. Ayala Kenneth J, Gadre Dhananjay V, "8051 Microcontroller and Embedded Systems", Cengage Learning.

Textbooks:

1. Muhammad Ali; Mazidi Janice Gillispie; McKinlay Rolin D, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", 2nd Edition, Dorling Kindersley.
2. The AVR Microcontroller and Embedded Systems Using Assembly and C, By Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi, Pearson Education.

For MOOCs and other learning Resources

1. https://archive.nptel.ac.in/courses/108/105/108105102/ (From Lecture 23 onwards)
2. https://nptel.ac.in/courses/117104072
3. https://www.coursera.org/learn/microcontroller-and-industrial-applications, Microcontroller and Industrial Applications. This course is part of Intelligent Digital Factories Specialization, Instructor: Subject Matter Expert

ICM001:: Sensor and Automation

Teaching Scheme : Theory: 2 Hours/Week**; Tutorial :** 1 Hours/Week

Total Credits: 2

Syllabus

Theory

Unit 1: Basic Measurement system

Basic Measurement System, Process system components, Static and Dynamic characteristic of sensor and system, Standards and calibrations, data sheet reading and discussion, working, construction and application of Different types of Flow measurement sensor system.

Unit 2: Process sensor

Working, construction and application of Different types of Temperature, Level and pressure sensor.

Unit 3: Environmental Sensor

Working, construction and application of PH, conductivity, Moisture, humidity, force, speed, displacement sensor, SMART sensor, MEMS sensor.

Unit 4: Industrial Control Devices

Switches: construction, working, terminologies and applications of different types of switches e.g. push button, micro, limit switches, toggle, slide, DIP, rotary, thumbwheel.

Relays: construction, working, terminologies and applications of different relays e.g. Electro-mechanical relay, reed relay, solid-state relays and timing relay, specifications.

Introduction to Motor control circuits: electrical wiring diagram for starting, stopping, reversing, sequencing and interlocking for motors. Protection of motors: short circuit, overload protection, low / under voltage, phase reversal, over temperature protection.

Unit 5: PLC and SCADA

PLC Hardware: Types of Processes, Advantages, Architecture of PLC, working of PLC, Scan time.

PLC Programming: Development of PLC Programming languages, Instructions SCADA components. Need of SCADA system, application & benefits, Types of SCADA System, Future trends.

Unit 6: Fundamental of Process control and Drives

Types of control systems: open loop, closed loop, feedback and feed forward control systems, Elements and variables involved in process control loop, Basics of different types of continuous and discontinuous Controller and their application.

construction, working, features, advantages, disadvantages, characteristics Different types of Motor like Stepper motor, AC and DC servomotor, DC Micro motors.

Drives : Need, Types, Selection criteria, Advantages and disadvantages of drives like VFD.

Tutorials

List of Tutorials

1. Study of static characteristic and calibration of any one flow sensor
2. Study of static characteristic and calibration of any one humidity sensor
3. Study of static characteristic and calibration of level sensor
4. Develop logic circuits using switches / relays.
5. Develop a Ladder program for simple applications.
6. Develop a Ladder program using timers and counters
7. To evaluate performance characteristics Thermocouple/RTD.
8. To evaluate performance of C-type bourdon gauge
9. To evaluate performance characteristics capacitive sensor
10. To evaluate static characteristics of different proximity sensor
11. Compare performance of electromagnetic flow meter and Rotameter.

Course Outcomes

At the end of this course, the students will be able to:

1. Understand working principle of different sensor
2. Able to evaluate characteristics of sensor
3. Select suitable sensor for given application
4. Comprehend the working of industrial control drives
5. Develop PLC programs for given application
6. Select and size the process control drives

Books and E-Resources

For Reference Print Book – Text Book

1. Nakra-Chaudhary, "Instrumentation Measurement and Analysis", Tata McGraw Hill Publications - 21 st Reprint.
2. A. K. Sawhney, "Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai and Sons Publications, 2002.
3. R. K. Jain, "Mechanical and Industrial Measurement", Khanna Publications - 9th print.
4. John Webb, "Programmable Logic Controllers", Prentice Hall of India.
5. B. L. Theraja, "Electrical Technology", S. Chand and Company.
6. F. D. Petruzella, "Industrial Electronics", Glancor Publications.

For Reference Book

1. B. G. Liptak, "Process Measurement and Analysis"
2. E.O. Doebelin, "Measurement System Application and Design", McGraw-Hill International Publications - Fourth Edition.
3. SCADA by Stuart A Boyer : ISA 1999
4. B. G. Liptak, "Process Control", Third Edition

For MOOCs and other learning Resources

1. https://onlinecourses.nptel.ac.in/noc23_ee95/preview, Prof. Mitradip Bhattacharjee Accessed 23rd May 24
2. https://onlinecourses.nptel.ac.in/noc21_ee32/preview, By Prof. Hardik Jeetendra Pandya | IISc Bangalore
3. https://onlinecourses.nptel.ac.in/noc21_me67/preview, By Prof. Siddhartha Mukhopadhyay | IIT Kharagpur

FF No. : 654

ICM002 :: Microcontroller and Applications

Teaching Scheme: Theory: 2 Hours/Week; **Tutorial : 1** Hour/Week
Total Credits: 2

Unit 1: Introduction to Microcontroller Applications in Robotics and Industrial Automation

Learning Objectives: Upon completion of this unit, students will be able to:

1. Understand the fundamental role of **microcontrollers** in modern robotics and industrial automation.
2. Identify common types of microcontrollers (e.g., **Arduino, Raspberry Pi, PLC**) and their primary applications.
3. Recognize key **sensors and actuators** used in robotic and automation systems.
4. Grasp basic programming concepts for microcontroller control relevant to these fields.

Syllabus Contents:

1. Overview of Microcontrollers in Robotics and Industrial Automation (1 hour)

- **1.1. Introduction to Robotics & Industrial Automation:** Brief definitions and why these fields are critical in modern engineering.
- **1.2. The Microcontroller's Role:** What a microcontroller is (CPU, memory, I/O) and why it's the "brain" for embedded control in robots and automated systems. Advantages like cost-effectiveness and real-time operation.
- **1.3. Control System Basics (Brief):** A quick look at the idea of feedback and control loops.

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2. Types of Microcontrollers Used (e.g., Arduino, Raspberry Pi, PLC) (1.5 hours)

- **2.1. Arduino Platform:** Introduction to Arduino as an easy-to-use, open-source platform. Highlight its simplicity for rapid prototyping and learning. Discuss its core features (ATmega chip, digital/analog I/O).
- **2.2. Raspberry Pi:** Overview of Raspberry Pi as a single-board computer. Contrast it with Arduino in terms of processing power and operating system presence. Mention its suitability for more complex tasks like vision processing.
- **2.3. Programmable Logic Controllers (PLCs):** Introduce PLCs as robust industrial controllers. Briefly explain their role in large-scale factory automation and the concept of **ladder logic** (without diving into programming details).
- **2.4. Choosing the Right Tool:** A quick guide on when to use Arduino vs. Raspberry Pi vs. PLC based on application needs.

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3. Sensors and Actuators in Robotics and Industrial Automation (1.5 hours)

- **3.1. Sensors - The "Eyes and Ears":**
  - **Proximity Sensors:** Inductive, optical (for object detection).
  - **Ultrasonic Sensors:** For distance measurement.
  - **Encoders:** For measuring position/speed in motors.
  - **Temperature Sensors:** For environmental or process monitoring.

- **3.2. Actuators - The "Muscles":**
    - **DC Motors:** Basic control for movement (e.g., wheels of a robot, conveyor).
    - **Stepper Motors:** For precise angular movements (e.g., robotic arms, 3D printers).
    - **Servo Motors:** For controlled angular positioning.
    - **Relays:** For switching larger loads.

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4. Basic Programming Concepts for Microcontrollers (1 hour)

- **4.1. Embedded C/C++ Fundamentals (Arduino-focused):**
    - Structure of an Arduino program (setup(), loop()).
    - Basic I/O functions: pinMode(), digitalWrite(), digitalRead().
    - Simple analog input (analogRead()) and output (analogWrite()).
    - **Simple Control Logic:** Using if-else statements for decision-making.
- **4.2. Practical Microcontroller Interaction:**
    - **Demonstration:** How to blink an LED.
    - **Demonstration:** Reading a push button to control an LED.
    - **Demonstration:** Simple motor control (ON/OFF).

Unit 2: Microcontrollers in Healthcare and Building Automation

Learning Objectives: Upon completion of this unit, students will be able to:

1. Identify diverse applications of microcontrollers in the **healthcare sector**, including medical devices and patient monitoring.
2. Understand the role of microcontrollers in various aspects of **building automation**, such as smart lighting, HVAC, and security.
3. Recognize key **sensors and communication protocols** commonly utilized in healthcare and building automation systems.
4. Analyze and describe basic microcontroller-based **case studies** in both healthcare and building automation.

Syllabus Contents:

1. **Microcontrollers in Healthcare Applications (1.5 hours)**

- **1.1. Introduction to Healthcare Technology:**
    - Brief overview of how technology impacts modern healthcare.
    - The need for embedded systems and real-time control in medical devices.
- **1.2. Medical Devices & Equipment:**
    - **Patient Monitoring Systems:** Role of microcontrollers in vital sign monitors (heart rate, SpO2, temperature, blood pressure). How data is acquired and processed.
    - **Infusion Pumps:** Basic concept of controlled fluid delivery; microcontroller's role in precision dosing and safety alarms.
    - **Diagnostic Tools (Brief):** Mention of microcontrollers in portable diagnostic devices (e.g., glucometers, ECG machines).

- **Wearable Health Devices:** Introduction to fitness trackers and smartwatches (how microcontrollers enable data collection and basic analysis).

- **1.3. Challenges & Considerations:**
  - Brief mention of regulatory compliance (e.g., safety, reliability) in medical device design.

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2. Microcontrollers in Building Automation (1.5 hours)

- **2.1. Introduction to Building Automation Systems (BAS) / Smart Buildings:**
  - Concept of integrated building control for comfort, energy efficiency, and security.
  - Why microcontrollers are central to "smart" functionalities.
- **2.2. Key Automation Areas:**
  - **Lighting Control:**
    - Automatic on/off based on occupancy (PIR sensors).
    - Daylight harvesting (light sensors).
    - Dimming control.
  - **HVAC (Heating, Ventilation, and Air Conditioning) Control:**
    - Smart thermostats: Temperature and humidity sensing, fan control.
    - Zone-based control for energy efficiency.
  - **Security Systems:**
    - Access control (door locks, card readers).
    - Surveillance integration (basic overview).
    - Intrusion detection (motion sensors, door/window contacts).
  - **Energy Management:** Basic concepts of optimizing energy usage in buildings using microcontroller data.

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2. Sensors and Communication Protocols (1 hour)

- **3.1. Common Sensors for Healthcare & Building Automation:**
  - **Healthcare:**
    - Temperature sensors (e.g., thermistors for body temp).
    - SpO2 sensors (concept of pulse oximetry).
    - Pressure sensors (for blood pressure cuffs, fluid levels).
    - PIR sensors (for fall detection in elder care).
  - **Building Automation:**
    - **Occupancy/Motion Sensors (PIR, Ultrasonic):** For lighting, HVAC control.
    - **Light Sensors (LDR, Photodiode):** For ambient light detection.
    - **Temperature & Humidity Sensors (DHT series, LM35):** For HVAC.
    - **Door/Window Contact Sensors:** For security.
- **3.2. Communication Protocols (Brief Overview):**
  - **Wired:** I2C, SPI (for internal component communication), RS-485 (for industrial building networks).
  - **Wireless:**
    - **Bluetooth/BLE:** For personal medical devices, smart home gadgets.
    - **Wi-Fi:** For broader network connectivity, data upload to cloud.

- **Zigbee/Z-Wave:** Common low-power mesh protocols for smart home devices.
- **LoRa/LoRaWAN (Brief Mention):** For long-range IoT applications.

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4. Case Studies & Project Examples (1 hour)

- **4.1. Healthcare Case Studies:**
  - **Simple Patient Monitor:** A conceptual design of an Arduino-based device measuring temperature and heart rate, displaying on an LCD. Discuss sensor integration and basic code logic.
  - **Smart Pill Dispenser (Conceptual):** How a microcontroller could remind patients and dispense medication based on a schedule.

- **4.2. Building Automation Case Studies:**
  - **Smart Lighting System:** A conceptual design for occupancy-based lighting control using a PIR sensor and an Arduino/ESP32, perhaps with dimming capability.
  - **Automated Room Climate Control:** Conceptual design of a system using a temperature sensor to control a fan/heater.
  - **Basic Door Access Control:** A simple system using a keypad or RFID reader and a servo/solenoid for locking/unlocking.

Unit 3: Asset Management and Predictive Maintenance with Microcontrollers

Unit 3: Asset Management and Predictive Maintenance with Microcontrollers

Learning Objectives: Upon completion of this unit, students will be able to:

1. Understand the application of microcontrollers in **asset management** systems, including tracking technologies.
2. Grasp the fundamental concepts of **predictive maintenance** and the role of microcontrollers in its implementation.
3. Identify essential **sensors and communication modules** required for building microcontroller-based asset management and predictive maintenance systems.
4. Analyze and describe practical **examples** of microcontroller-driven solutions in these domains.

Syllabus Contents:

1. Asset Management Applications with Microcontrollers (1.5 hours)

- **1.1. Introduction to Asset Management:**
  - Definition and importance of asset management in industries (e.g., manufacturing, logistics, healthcare).
  - Benefits: Inventory control, theft prevention, improved utilization.
  - Role of microcontrollers in real-time data collection and processing for assets.

- **1.2. Asset Tracking Technologies:**
    - **RFID (Radio-Frequency Identification) Tracking:**
        - Basic principle: Tags (passive/active) and readers.
        - How microcontrollers interface with RFID readers.
        - Applications: Warehouse inventory, tool tracking, access control for assets.
    - **GPS (Global Positioning System) Tracking:**
        - Basic principle of GPS for location determination.
        - Integration of GPS modules with microcontrollers.
        - Applications: Fleet management, tracking high-value mobile assets (e.g., construction equipment, vehicles).
    - **Barcode/QR Code (Brief Mention):** Simple identification; comparison with RFID.
- **1.3. Data Flow:** How tracking data is collected by microcontrollers and potentially transmitted for central processing.

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2. Predictive Maintenance (PdM) with Microcontrollers (1.5 hours)

- **2.1. Introduction to Maintenance Strategies:**
    - Brief comparison: Breakdown maintenance vs. Preventive maintenance vs. Predictive maintenance.
    - Advantages of PdM: Reduced downtime, optimized maintenance schedules, extended asset life, cost savings.
- **2.2. Microcontroller's Role in PdM:**
    - Continuously monitoring equipment parameters.
    - Processing sensor data to identify anomalies or degradation.
    - Triggering alerts for impending failures.
- **2.3. Key Monitoring Parameters for PdM:**
    - **Vibration Analysis:**
        - Importance of vibration as an indicator of machine health (bearings, unbalance, misalignment).
        - Microcontroller interfacing with accelerometers (e.g., ADXL345).
        - Basic concept of data collection and thresholding.
    - **Temperature Monitoring:**
        - Overheating as a sign of friction, electrical faults.
        - Microcontroller interfacing with temperature sensors (e.g., LM35, thermistors, non-contact IR sensors).
    - **Other Parameters (Brief Mention):** Current consumption, pressure, acoustic monitoring.

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3. Integration of Microcontrollers with Sensors and Communication Modules (1 hour)

- **3.1. Sensor Integration:**
    - Review of sensor types relevant to asset tracking and PdM (accelerometers, temperature, RFID readers, GPS modules).

- Interfacing techniques: Analog-to-Digital Conversion (ADC), I2C, SPI.

- **3.2. Communication Modules for Data Transmission:**
  - **Local Communication (for module-to-microcontroller):** UART, I2C, SPI.
  - **Remote Communication (for data to central system/cloud):**
    - **Wi-Fi Modules (e.g., ESP8266, ESP32):** For local network connectivity, sending data to a dashboard.
    - **GSM/GPRS Modules:** For cellular communication (SMS alerts, data upload from remote locations).
    - **LoRa/LoRaWAN (Brief Mention):** For low-power, long-range wireless data transmission in large facilities.

- **3.3. Basic Data Processing on Microcontroller:**
  - Filtering noisy sensor data.
  - Setting thresholds for alerts.
  - Timestamping data.

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4. Examples of Microcontroller-Based Systems (1 hour)

- **4.1. Asset Management System Examples:**
  - **RFID-based Tool Tracking:** Conceptual design of a system where tools in a workshop are tracked as they enter/leave an area, using an Arduino/ESP32 with an RFID reader.
  - **Vehicle Tracking:** A simple block diagram showing how a GPS module, microcontroller, and GSM module could track a vehicle's location and send periodic updates.
- **4.2. Predictive Maintenance System Examples:**
  - **Motor Health Monitoring:** Conceptual design of an Arduino/ESP32-based system monitoring a small motor's vibration (using an accelerometer) and temperature (using a temperature sensor). If thresholds are exceeded, an alert is sent via Wi-Fi/serial.
  - **Conveyor Belt Condition Monitoring:** How a microcontroller could monitor the temperature of critical bearings on a conveyor and trigger an alarm.
- **4.3. System Architecture (Simplified):** A high-level overview of how data flows from sensor to microcontroller, then via a communication module to a monitoring system or cloud.

Unit 4: Smart Manufacturing and Industry 4.0 with Microcontrollers

Learning Objectives: Upon completion of this unit, students will be able to:

1. Define **Smart Manufacturing** and understand the core principles of **Industry 4.0**.
2. Explain the pivotal **role of microcontrollers** in enabling key Industry 4.0 technologies like IoT and data collection.
3. Identify essential **communication protocols and standards** used in smart manufacturing environments.
4. Analyze and describe basic **case studies** of microcontroller-based smart manufacturing projects.

Syllabus Contents:

1. Overview of Smart Manufacturing and Industry 4.0 (1 hour)

- **1.1. Introduction to Industry 4.0:**
  - Definition and historical context (from Industry 1.0 to 4.0).
  - Key pillars of Industry 4.0: IoT, Big Data, Cloud Computing, Cyber-Physical Systems (CPS), AI/ML, Robotics, Additive Manufacturing.
  - Vision of the "Smart Factory" and interconnected systems.
- **1.2. Smart Manufacturing Concepts:**
  - Definition and goals: Increased efficiency, flexibility, customization, quality, and cost reduction.
  - Importance of real-time data and connectivity in manufacturing.
  - Brief mention of digital twin concept.

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2. Role of Microcontrollers in Smart Manufacturing (1 hour)

- **2.1. Microcontrollers as Edge Devices:**
  - Position of microcontrollers at the "edge" of the network – interacting directly with machinery and processes.
  - Data acquisition from sensors on production lines.
  - Local control and pre-processing of data.
- **2.2. Enabling IoT in Manufacturing (IIoT - Industrial IoT):**
  - How microcontrollers connect machines, sensors, and actuators to the internet.
  - Role in collecting data from disparate sources (e.g., machine status, production counts, environmental conditions).
  - Sending data to higher-level systems (cloud, SCADA, MES).
- **2.3. Data Analytics Foundation:**
  - Microcontrollers providing the raw, reliable data for analytics at the cloud or server level.
  - Brief mention of how local processing (e.g., simple filtering, aggregation) can reduce data load.

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3. Communication Protocols and Standards in Smart Manufacturing (1 hour)

- **3.1. Why Protocols are Essential:** Ensuring seamless communication between diverse devices and systems.
- **3.2. Common IIoT Protocols (Microcontroller-Centric):**
  - **MQTT (Message Queuing Telemetry Transport):**
    - Lightweight, publish-subscribe protocol ideal for resource-constrained devices (microcontrollers).
    - Concepts of broker, publisher, subscriber, topics.
    - Advantages for unreliable networks and low bandwidth.
  - **CoAP (Constrained Application Protocol):**
    - Similar to HTTP but optimized for constrained devices and networks.
    - Request-response model.
    - Suitability for battery-powered sensors.
  - **HTTP/HTTPS (Brief Mention):** For direct web server interaction, often via Wi-Fi modules.
- **3.3. Industrial Communication (Brief Mention):**

- Modbus, Profibus, Ethernet/IP (Higher-level protocols often handled by PLCs/gateways, but good for context).
- The role of gateway devices (often microcontroller/SBC-based) to bridge protocols.

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4. Case Studies of Microcontroller-Based Smart Manufacturing Projects (1 hour)

- **4.1. Real-time Production Monitoring:**
  - **Example:** Using a microcontroller (e.g., ESP32) to count products on a conveyor belt (IR sensor) and send production data (MQTT) to a dashboard for real-time visualization.
  - Discussion on how this improves efficiency and identifies bottlenecks.
- **4.2. Condition Monitoring for Equipment:**
  - **Example:** A microcontroller-based node monitoring the temperature and vibration of a critical machine component (using accelerometers and thermistors). Data is sent wirelessly (Wi-Fi/LoRa) for predictive maintenance.
  - How this prevents unexpected breakdowns.
- **4.3. Automated Quality Control:**
  - **Example:** A simple microcontroller system with a color sensor to detect product defects (e.g., wrong color components) and trigger an alert or rejection mechanism.
- **4.4. Energy Monitoring in a Factory:**
  - **Example:** Microcontrollers interfacing with current/voltage sensors to monitor power consumption of individual machines or factory sections, providing data for energy optimization.

Unit 5: Communication Networks

Learning Objectives: Upon completion of this unit, students will be able to:

1. Understand the fundamental concepts of **serial communication**.
2. Differentiate between common **wired communication protocols** (UART, SPI, I2C) and their applications.
3. Explain the principles and applications of key **wireless communication technologies** (Wi-Fi, Bluetooth, Zigbee, LoRaWAN).
4. Grasp the basic working of **industrial communication buses** (Modbus, CAN).
5. Select appropriate communication protocols for given embedded system applications.

Syllabus Contents:

1. Introduction to Communication Networks & Concepts (0.5 hours)

- **1.1. Why Communication is Essential:** Need for devices to exchange data in embedded systems, IoT, and industrial automation.
- **1.2. Basic Concepts:**
  - Serial vs. Parallel Communication (brief overview).
  - Simplex, Half-duplex, Full-duplex.
  - Master-Slave vs. Peer-to-Peer communication models.
  - Baud Rate, Data Rate, Latency.

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2. Wired Communication Protocols (2 hours)

- **2.1. UART (Universal Asynchronous Receiver/Transmitter):**

    - **Principle:** Asynchronous serial communication, transmit (Tx) and receive (Rx) lines.
    - **Working:** Start bit, data bits, parity bit, stop bit.
    - **Applications:** Debugging (Serial Monitor), communication with GPS modules, GSM modules, Bluetooth modules.
    - **Advantages/Disadvantages:** Simplicity, dedicated lines vs. no clock, limited range.
- **2.2. SPI (Serial Peripheral Interface):**
    - **Principle:** Synchronous serial communication, full-duplex.
    - **Working:** Master-Slave architecture, four wires (MOSI, MISO, SCK, SS/CS).
    - **Applications:** Communication with SD cards, LCD displays, Flash memory, ADC/DAC converters.
    - **Advantages/Disadvantages:** High speed, full-duplex vs. more pins, dedicated slave select for each slave.
- **2.3. I2C (Inter-Integrated Circuit):**
    - **Principle:** Synchronous serial communication, half-duplex, multi-master/multi-slave.
    - **Working:** Two wires (SDA - data, SCL - clock), address-based communication.
    - **Applications:** Communication with sensors (temperature, accelerometer, gyroscope), EEPROMs, RTCs.
    - **Advantages/Disadvantages:** Few pins, supports multiple devices vs. slower than SPI, more complex addressing.

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3. Wireless Communication Protocols (1.5 hours)

- **3.1. Wi-Fi (Wireless Fidelity):**
    - **Principle:** Based on IEEE 802.11 standards, WLAN.
    - **Working:** Connecting to existing networks, client-server model.
    - **Applications:** IoT devices, sending data to cloud, web servers on embedded systems (e.g., ESP32/ESP8266).
    - **Advantages/Disadvantages:** High bandwidth, wide adoption vs. higher power consumption.
- **3.2. Bluetooth:**
    - **Principle:** Short-range wireless technology, personal area networks (PANs).
    - **Working:** Pairing devices, master-slave.
    - **Types:** Classic Bluetooth, Bluetooth Low Energy (BLE).
    - **Applications:** Wearables, wireless audio, short-range device control, medical devices.
    - **Advantages/Disadvantages:** Low power (BLE), ad-hoc networks vs. limited range, lower data rate than Wi-Fi.
- **3.3. Zigbee:**
    - **Principle:** Low-power, low-data rate, mesh networking protocol (IEEE 802.15.4).
    - **Working:** Coordinator, router, end-device roles.
    - **Applications:** Smart home automation (lighting, HVAC), industrial monitoring, sensor networks.
    - **Advantages/Disadvantages:** Mesh networking, very low power vs. lower data rate, less common than Wi-Fi/Bluetooth.

- **3.4. LoRaWAN (Long Range Wide Area Network):**
    - **Principle:** LPWAN technology for long-range, low-power communication.
    - **Working:** Star-of-stars topology, gateways.
    - **Applications:** Smart cities, agriculture, asset tracking, remote sensor monitoring.
    - **Advantages/Disadvantages:** Extremely long range, very low power vs. low data rate, requires infrastructure.

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4. Industrial Communication Buses (1 hour)

- **4.1. Modbus:**
    - **Principle:** Master-slave protocol for communication between industrial electronic devices.
    - **Types:** Modbus RTU (serial), Modbus TCP/IP (Ethernet).
    - **Working:** Function codes for reading/writing data (coils, registers).
    - **Applications:** PLCs, HMIs, sensors, actuators in industrial automation.
    - **Advantages/Disadvantages:** Simplicity, widely adopted vs. limited addressing, no built-in security.
- **4.2. CAN (Controller Area Network):**
    - **Principle:** Message-based protocol designed for robust, real-time communication.
    - **Working:** Broadcast communication, arbitration, error detection.
    - **Applications:** Automotive electronics (engine control, ABS), industrial automation, medical equipment.
    - **Advantages/Disadvantages:** High reliability, robust error handling, multi-master vs. limited data payload per message.
- **4.3. Selection Criteria (Brief):** Factors influencing protocol choice (speed, range, power, cost, number of devices, reliability).

Unit 6: Advanced Topics in Microcontroller Applications

Learning Objectives: Upon completion of this unit, students will be able to:

1. Understand the basic concepts of Machine Learning (ML) and its relevance to embedded systems.
2. Identify practical applications of ML on microcontrollers (TinyML).
3. Grasp the foundational ideas behind Computer Vision (CV).
4. Recognize how CV concepts are implemented in microcontroller-based systems.
5. Appreciate the potential and limitations of running ML and CV models on resource-constrained microcontrollers.

Syllabus Contents:

1. Introduction to Machine Learning (ML) on Microcontrollers (TinyML) (1.5 hours)

- **1.1. What is Machine Learning?**
    - Brief overview: Defining ML as learning from data without explicit programming.
    - Types of ML (supervised, unsupervised, reinforcement learning - very brief conceptual).
    - Why ML is powerful: Pattern recognition, prediction, classification.
- 1.2. The Rise of TinyML:

    - Concept: Running ML models on resource-constrained devices (microcontrollers).
    - Why it's important: Edge computing, real-time inference, privacy, low power consumption.
    - Challenges: Limited memory (RAM/Flash), limited processing power (CPU frequency), power budget.
- 1.3. Applications of TinyML:
    - Keyword Spotting/Voice Control: "Hey Google," "Alexa" wake words.
    - Anomaly Detection: Monitoring machine health (e.g., vibration, temperature) for unusual patterns.
    - Simple Gesture Recognition: Recognizing hand movements for control.
    - Predictive Maintenance: Using sensor data to predict equipment failure (revisiting from Unit 3, but now with ML).
    - Activity Recognition: Identifying human activities (e.g., walking, running) from accelerometer data.
- 1.4. Overview of TinyML Workflow (High-Level):
    - Data collection (on microcontroller).
    - Model training (on powerful PC/cloud).
    - Model conversion/optimization (e.g., TensorFlow Lite Micro).
    - Deployment (flashing to microcontroller).
    - Inference (running the model on the microcontroller).

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2. Introduction to Computer Vision (CV) on Microcontrollers (1.5 hours)

- 2.1. What is Computer Vision?
    - Defining CV: Enabling computers to "see" and interpret visual information (images/video).
    - Basic concepts: Image processing, feature extraction, object recognition.
- 2.2. Challenges of CV on Microcontrollers:
    - High computational demands of image processing.
    - Memory requirements for image buffers.
    - Low frame rates, limited resolution due to resource constraints.
- 2.3. Applications of CV on Microcontrollers:
    - Object Detection/Counting: Simple detection of specific objects (e.g., counting items on a conveyor, presence detection).
    - QR Code/Barcode Reading: Decoding simple visual patterns.
    - Basic Facial Features/Presence Detection: Not full facial recognition, but detecting if a face is present.
    - Anomaly Detection in Images: Detecting simple visual defects on a production line.
    - Line Following Robots: Using simple camera modules for line detection.
- 2.4. Key Components for CV on Microcontrollers:
    - Camera Modules: OV7670, ESP32-CAM (low-cost, low-resolution).
    - Microcontrollers with sufficient RAM/processing: ESP32, higher-end ARM Cortex-M series.
    - Specialized Libraries/Tools: OpenMV, Edge Impulse (for simplified CV model deployment).

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3. Practical Considerations and Future Trends (1 hour)

- **3.1.** Selecting the Right Microcontroller:
    - Criteria based on ML/CV needs (RAM, Flash, clock speed, integrated peripherals).
    - Brief comparison: ESP32 vs. ARM Cortex-M4/M7 for advanced applications.
- 3.2. Tools and Frameworks (Conceptual):
    - TensorFlow Lite Micro (for deploying ML models).
    - Edge Impulse (platform for data collection, training, and deployment for TinyML/CV).
    - OpenCV (very brief mention of its basic functions, not for direct microcontroller use unless highly optimized).
- 3.3. Limitations and Future Directions:
    - Current limitations: Model complexity, accuracy, real-time performance.
    - Emerging trends: Hardware accelerators (NPU/AI cores on MCUs), more optimized ML frameworks, smaller model architectures.
    - The impact on embedded systems, IoT, and edge AI.

Syllabus : Tutorial

1. Microcontroller used for various applications
2. Getting Started with Arduino IDE & First Program
3. Controlling an LED with a Push Button
4. Controlling a DC Motor
5. Temperature & Humidity Monitoring with DHT11/DHT22 Sensor
6. Occupancy Detection using a PIR Sensor
7. Simple Smart Home Lighting (LDR-based Automatic Light)
8. Interfacing an Accelerometer (ADXL345) for Vibration Data
9. RFID Tag Reading for Basic Asset Identification
10. GPS Data Acquisition with NEO-6M Module
11. ESP32 Wi-Fi Basics: Connecting to a Network & Web Server
12. Publishing Sensor Data to MQTT Broker using ESP32
13. Basic Product Counting with an IR Sensor and ESP32
14. UART Communication between Two Arduinos
15. I2C Communication: Master-Slave with Multiple Sensors
16. SPI Communication: Arduino with an SD Card Module
17. Theorical tutorials for various use cases
18. Various tutorial based on virtual labs: **Tinkercad Circuits (Autodesk Tinkercad)**
    Link: https://www.tinkercad.com/circuits
    Wokwi Arduino Simulator

- **Link:** https://wokwi.com/
  Proteus Design Suite (Requires Software Installation, but widely used for virtual labs)
- **Link:** https://www.labcenter.com/

Virtual Robotics Lab **V-REP (CoppeliaSim)** or **ROS-Gazebo**
Vibration Analysis Data Visualization (using Python/Jupyter Notebook in cloud)

- **Resource:** Platforms like **Google Colab** (https://colab.research.google.com/) or **JupyterLite** (https://jupyter.org/try-jupyter/lab)

Online GPS Trackers (Web-based Interfaces)

- **Resource:** Use public web-based GPS tracking interfaces (e.g., for vehicle fleets or simple object tracking if a public demo is available).

MQTT Broker Simulators / Test Clients (Online)

- **Resource:** Websites like **HiveMQ MQTT Client** (https://www.hivemq.com/demos/websocket-client/) or **MQTT Explorer** (desktop app, but conceptual). Wokwi also has MQTT capabilities.

Node-RED for IIoT Dashboarding (Online Demo Instances)

- **Resource:** Node-RED has public demo instances or "try it" links (https://nodered.org/).

UART/Serial Communication Simulators (Part of Tinkercad/Wokwi)

- **Resource: Tinkercad Circuits** and **Wokwi Arduino Simulator** are excellent for this. They include a serial monitor that shows the data being sent and received over UART.

I2C & SPI Communication Simulators (Part of Wokwi/Proteus)

- **Resource: Wokwi** has good support for simulating I2C sensors (e.g., connecting a virtual MPU6050) and SPI devices. Proteus also offers advanced simulation for these buses.

Edge Impulse Studio (Online TinyML Platform)

- **Link:** https://www.edgeimpulse.com/

Course Outcomes:

At the end of the course, the students will be able to:

1. Understand the fundamentals and importance of asset inventory and performance management in industrial systems.

Books and E-Resources

For Reference Print Book -

1. Asset Management: A Complete Guide" by John Woodhouse
2. Industrial Internet of Things: Technologies and Applications" by Fei Hu
3. Managing Industrial Assets: A Practical Guide for Professionals" by Andrew P. Ginder
4. RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Data Communication, and Supply Chain Management" by Klaus Finkenzeller
5. Wireless Sensor Networks: An Introduction" by Ian F. Akyildiz and Mehmet Can Vuran
6. Practical Industrial Internet of Things for Decision Makers" by B. B. Gupta, Dharma P. Agrawal, et al.
7. Asset Performance Management: An Introductory Guide" by Vivek Singh and Saurabh Gupta
8. Big Data Analytics in Industrial IoT" by Madhusanka Liyanage, Andrei Gurtov, et al.

9. Reliability, Maintainability and Risk: Practical Methods for Engineers" by David J. Smith
10. Maintenance Engineering Handbook" by Lindley R. Higgins, R. Keith Mobley, et al.
11. Predictive Maintenance in Smart Factories: AI-driven Techniques and Tools" by Mohamed Ben Halima and N. N. Ben Hamida
12. Condition-Based Maintenance: A Practical Guide for Engineers and Managers" by Muralidharan G.
13. Industrial Communication Systems" by Bogdan M. Wilamowski and J. David Irwi

For Reference Electronic Book –

1. The 8051 Microcontroller and Embedded Systems using Assembly and C" by Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay
2. Arduino Cookbook" by Michael Margolis
3. Sensors and Transducers" by D. Patranabis
4. Internet of Things: A Hands-On Approach" by Arshdeep Bahga and Vijay Madisetti
5. Embedded Systems Design: A Unified Hardware/Software Introduction" by Frank Vahid and Tony Givargis
6. TinyML: Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers" by Pete Warden and Daniel Situnayake
7. Practical Industrial Internet of Things (IIoT) Security" by David J. Puglia, Gary D. Kessler, and Douglas S. Maughan
8. Industrial Automation and Robotics" by A.K. Gupta and S.K. Saha
9. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" by David Hanes, Gonzalo Salgueiro, Robert Barton, Jerome Henry, Evan Tsang, Erik Petersen, and Roger Dixon
10. Predictive Maintenance in Industry 4.0: Challenges and Solutions"
11. Smart Manufacturing: Applications and Technologies" by R. Anandan, Suseendran Gopalakrishnan, Souvik Pal, and Noor Zaman
12. Data Communications and Networking" by Behrouz A. Forouzan
13. Embedded Machine Learning: From Concepts to Practical Applications" by Mohammed Fouda
14. Computer Vision: Algorithms and Applications" by Richard Szeliski

For MOOCs and other learning Resources

1. Embedded Systems - Shape The World" (UTAustinX / edX)
2. Microcontroller and Industrial Applications" (L&T EduTech / Coursera)
3. Fundamentals of Robotics & Industrial Automation" (L&T EduTech / Coursera)
4. An Introduction to Programming the Internet of Things (IOT)" (University of California, Irvine / Coursera Specialization)
5. Tiny Machine Learning (TinyML) Professional Certificate" (HarvardX / Google TensorFlow / edX)

Multidisciplinary Minor

ITM001: IOT and CLOUD

Teaching Scheme:

Theory: 2 Hours / Week

Tutorial: 1 Hours / Week

Total Credits: 3

Syllabus Theory

Unit 1: (Introduction to IoT and IoT Cloud Platforms) - (… Hours)

Overview of IoT technology and its applications, Role of cloud computing in IoT, Types of IoT platforms: Connectivity, Device Management, Application Enablement and Analytics. Introduction to AWS IoT, Google Cloud IoT, Microsoft Azure, IBM Watson IoT, Comparison of free and paid IoT cloud platforms (Blynk, Things Board, Thinger.io, Node-RED, etc.)

Unit 2: (IoT Hardware, Sensors, and Connectivity) - (… Hours)

Introduction to IoT hardware: Arduino, ESP32, Raspberry Pi., Understanding IoT sensors: Temperature, Humidity, Motion, Light, Pressure, Gas sensors, etc. Context sensing and awareness. Communication protocols in IoT: Wi-Fi, Bluetooth, Zigbee, LoRaWAN, MQTT, and CoAP, HTTP. Introduction to Edge Computing and FreeRTOS.

Unit 3: (Cloud Connectivity & Data Transmission) - (… Hours)

Introduction to IoT Cloud Architecture. Setting up AWS IoT Core, Google Cloud IoT, and IBM Watson IoT. Data transmission using MQTT, HTTP, and WebSockets. Time-series databases for IoT: InfluxDB and Thing Speak. Storing and retrieving sensor data from AWS IoT Core and Google Cloud IoT

Unit 4: (IoT Device Management & Security) - (… Hours)

Onboarding & managing IoT devices on AWS IoT Device Management. Understanding device authentication & secure communication protocols (TLS, X.509 Certificates). Implementing AWS IoT Device Defender for security audits. Security challenges in IoT and best practices for securing IoT cloud systems.

Unit 5: (IoT Cloud Analytics & Real-Time Processing:) - (… Hours)

Introduction to IoT data analytics. Streaming and analyzing data with AWS IoT Events, Google Cloud IoT, and IBM Watson IoT. Using InfluxDB for time-series data analysis. **(Self-Study -** Developing IoT dashboards with Grafana and Node-RED**)**

Unit 6: (IoT and Cloud Applications:) - (… Hours)

Edge computing with AWS IoT Greengrass. Developing end-to-end IoT cloud applications. Case studies: Smart Home, Smart Agriculture, Wearables. **(Self-Study-** Industrial IoT**)**

Syllabus

Tutorials

List of Tutorials

1. Exploring IoT Platforms: AWS, Google Cloud, Azure, and IBM Watson
2. Setting Up and Programming IoT Hardware (Arduino, ESP32, Raspberry Pi)
3. Sensor Integration and Data Acquisition in IoT Systems
4. Protocol Comparison: Wi-Fi, Zigbee, LoRaWAN, MQTT, CoAP, and HTTP
5. Introduction to Edge Computing and FreeRTOS Basics
6. Cloud Connectivity: Sending Data to AWS IoT Core via MQTT
7. Cloud Storage and Visualization using ThingSpeak and InfluxDB
8. Device Management using AWS IoT Device Management Console
9. Implementing Secure IoT Communication with TLS and X.509 Certificates
10. Streaming Analytics using AWS IoT Events and Google Cloud IoT Core
11. Building Custom Dashboards in Node-RED and Grafana
12. Case Study Workshop: Smart Agriculture or Smart Home Cloud Application

Course Outcomes

On completion of the course, learner will be able to–

1. Elaborate leading commercial IoT cloud platforms and IOT hardware
2. Provide a comprehensive understanding of IoT technology and its real-world applications
3. Understand device authentication & secure communication protocols with best practices for securing IoT cloud systems
4. Analyse and develop IoT applications for diverse industries

Books and E-Resources

For Reference Print Book -

1. AWS IoT Cloud for Developers & Architects: Build highly secure and scalable IoT solutions with AWS IoT platform by Rabi Prasad Padhy (Unit:1)
2. IoT and Edge Computing for Architects 2nd Edition by Perry Lea (Author) (Unit:2)
3. Mastering Internet of Things: Design and create your own IoT applications using Raspberry Pi 3(Unit:3)
4. Demystifying Internet of Things Security: Successful IoT Device/Edge and Platform Security Deployment 1st ed. Edition by Sunil Cheruvu (Author), Anil Kumar (Author), Ned Smith (Author), David M. Wheeler (Author)(Unit:4)
5. An Introduction to IoT Analytics (Chapman & Hall/CRC Data Science Series)1st Edition by Harry G. Perros (Author) (Unit:5,6)

For Reference Electronic Book –

1. Author initials, Author Surname (for Author 1), Author initials, Author Surname (for Author 2); 'Title of the E-Book'; Edition; Publisher; Year of Publication; Accessed — Abbreviated Month, Day and Year; Available- Provide Site / Path /File (Database or URL); DOI if available
   Example - H. Schmidt-Walter, R. Kories; 'Electrical Engineering. A Pocket Reference'; Artech House, 2007. Accessed: Oct. 16, 2016. [Online]. Available: https://ebookcentral.proquest.com

For MOOCs and other learning Resources

2. Instructor initials, Instructor Surname (for Instructor 1), Instructor initials, Instructor Surname (for Instructor 2); 'Title of the Course'; Platform; URL – Full Web Address; ; Accessed — Abbreviated Month, Day and Year
   Example — M. O. Jackson, K. Leyton-Brown; Y. Shoham; ' Game Theory'; Coursera; https://www.coursera.org/learn/game-theory-1; Accessed: Apr. 23, 2024

Multidisciplinary Minor

ITM002: Ethical Hacking

Teaching Scheme:

Theory: 02 Hours / Week

Tutorial: 01 Hours / Week Total

Credits: 03

Syllabus Theory

Unit I : Introduction to Network and security
Basics of Computer Networks: OSI Model, TCP/IP Model, Network topology (Physical & logical), Network Hardware Components: Connectors, Repeaters, hubs, NICs, Bridges and Switches.
Basics of Computer Networks Security: Essential Terminology, Elements of Information Security, Types of Hackers, Steps for Ethical hacking, Types of Attacks.

Unit II : Legal Perspective
The Indian IT Act, Challenges to Indian law, Cybercrime scenario in India, 2008 amendments to Indian IT Act, Intellectual property in the cyberspace.

Unit III Information Gathering Techniques
Active information gathering, passive information gathering, Trace route, Interacting with DNS Servers, SNMP and SMTP attacks.

Unit IV : Port Scanning and Vulnerability Assessment
Target Enumeration and Port Scanning Techniques: Scanning for Open Ports and Services, Types of Port Scanning, Firewall/IDS Evading Techniques
Vulnerability Assessment: Vulnerability Scanners and How Do They Work, Pros and Cons of a Vulnerability Scanner, Vulnerability Assessment with Nmap, Nessus

Unit V : Network Sniffing
Introduction, Types of Sniffing, ARP Protocol Basics, ARP Attacks, Denial of Service Attacks, Man in the Middle Attacks.

Unit VI : Remote Exploitation
Understanding Network Protocols: TCP,UDP,ICMP, Server Protocols: FTP,HTTP,SMTP

Syllabus
Tutorial

Sr. No.	Title of Tutorial
1	Linux Commands (use www.tryhackme.com) i) Basic Commands- Command, echo, whoami ii) File System Commands- command, ls, cd, cat , pwd iii) Searching for files- find, grep iv) Shell Operators
2	Exploring Network Scanning and Security Analysis Using Nmap (www.tryhackme.com) i) Nmap Switches ii) TCP connect Scans iii) SYN Scans iv) UDP Scans v) NULL, FIN and Xmas vi) ICMP Network Scanning vii) NSE Scripts viii) Working with NSE ix) Searching for Scripts x) Firewall Evasion
3	etwork Services (use www.tryhackme.com) i) Get Connected ii) Understanding, Enumerating, Exploiting SMB iii) Understanding, Enumerating, Exploiting Telnet iv) Understanding, Enumerating, Exploiting FTP v) Understanding, Enumerating, Exploiting NFS vi) Understanding, Enumerating, Exploiting SMTP vii) Understanding, Enumerating, Exploiting MySQL
4	HTTP (use www.tryhackme.com) i) Requests and Responses ii) HTTP Methods iii) HTTP status codes iv) Headers v) Cookies vi) Making Requests
5	Using Shodan Search Engine (https://www.shodan.io/) **Find all HTTP servers running on port 8080 in India.** o Use filters: port, country o Example format: port:8080 country:"IN"

6 Using Shodan Search Engine (https://www.shodan.io/)
Search for devices running Apache servers in any country.
- Use filters: product, country
- Example format: product:Apache country:"US"

7 Using Shodan Search Engine (https://www.shodan.io/)
Find webcams in any country that are accessible via HTTP.
- Use filters: country, port, title or http.title
- Example format: country:JP port:80 title:webcam

8 Using Shodan Search Engine (https://www.shodan.io/)
Track IoT devices using the "Server" header containing "GoAhead".
- Use filters: http.headers.server
- Example format: http. headers. server:"GoAhead"

9 Complete Certification of Qualys (any 2) (use https://www.qualys.com/training/)
1) Vulnerability Management Detection and Response (VMDR)
2) PCI Compliance
3) Vulnerability Management
4) Endpoint Detection and Response
5) Policy Compliance

Text Books :

1 Rafay baloch, "Ethical hacking and Penetration Testing guide", CRC press, 2015, ISBN: 13: 978-1-4822-3162-5 (eBook - PDF)

2 Nina Godbole, SunitBelapure, "Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives", WILEY Publications, 2015, ISBN:978-81-265-2179-1

Reference Books :

1 Behrouz Fourzon, " Data Communication and Computer Networks", Pearson Education,5th edition ISBN : 978-0070634145

2 Andrew S. Tanenbaum, " Computer Networks", International Economy Edition, 5th edition ISBN: 10: 9332518742

Course Outcomes

After completion of the course, student will be able to

1. Use basics knowledge of network security and hacking
2. Understand and use the IT Laws as and when required
3. Gather required information to perform a attack
4. Use various tools and methods for Vulnerability Assessment
5. Perform different attacks on Dummy scenario
6. Analyze the use of protocols studied

Multidisciplinary Minor

ITM003: COMPUTER GRAPHICS

Teaching Scheme:
Theory: 02 Hours / Week
Tutorial: 01 Hours / Week Total
Credits: 03

Syllabus

Theory

Unit 1 : Introduction to Computer Graphics (5 Hours)

Overview of Computer Graphics, Computer Graphics Application and Software, Description of some graphics devices, Input Devices for Operator Interaction, Active and Passive Graphics Devices, Display Technologies, Storage Tube Graphics Displays, Calligraphic Refresh Graphics Displays, Raster Refresh (Raster-Scan) Graphics Displays, Cathode Ray Tube Basics, Color CRT Raster Scan Basics, Video Basics, The Video Controller, Random-Scan Display Processor, LCD displays.

Unit 2 : Polygons and Clipping (5 Hours)

Scan Converting Lines, Mid-point criteria, Problems of Aliasing, end-point ordering and clipping lines, Scan Converting Circles, Scan Converting Ellipses, Filling Polygons, edge data structure, Clipping Lines algorithms– Cyrus-Beck, Cohen-Sutherland and Liang-Barsky, Clipping Polygons, problem with multiple components.

Unit 3 : 2D Transformation (4 Hours)

Transformations and Matrices, Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Transformation of Points, Transformation of The Unit Square, Solid Body Transformations, Rotation About an Arbitrary Point, Reflection through an Arbitrary Line, A Geometric Interpretation of Homogeneous Coordinates, The Window-to-Viewport Transformations. Inverse Transformations

Unit 4 : 3D Transformations and Projections (4 Hours)

Introduction, Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation, Three-Dimensional Reflection, Three-Dimensional Translation, Multiple Transformation, Rotation about an Arbitrary Axis in Space, Reflection through an Arbitrary Plane, Matrix Representation of 3D Transformations, Composition of 3D Transformations, Affine and Perspective Geometry, Perspective Transformations, Techniques for Generating Perspective Views, Vanishing Points, the Perspective Geometry and camera models, Orthographic Projections, Axonometric Projections, Oblique Projections, View volumes for projections.

Stages in 3D viewing, Canonical View Volume (CVV), Specifying an Arbitrary 3D View, Examples of 3D Viewing, The Mathematics of Planar Geometric Projections.

Unit 5: Illumination Models and Visible Surface Determination (5 Hours)

Illumination and Shading Models for Polygons, Reflectance properties of surfaces, Ambient, Specular and Diffuse reflections, Atmospheric attenutation, Phong's model, Gouraud shading, some examples.

Techniques for efficient Visible-Surface Algorithms, Categories of algorithms, Back face removal, The z-Buffer Algorithm, Scan-line method, Painter's algorithms (depth sorting), Area sub-division method, BSP trees, Visible-Surface Ray Tracing, comparison of the methods.

Unit 6 : Plane Curves and Surfaces (5 Hours)

Curve Representation, Nonparametric Curves, Parametric Curves, Parametric Representation of a Circle, Parametric Representation of an Ellipse, Parametric Representation of a Parabola, Parametric Representation of a Hyperbola, A Procedure for using Conic Sections, The General Conic Equation; Representation of Space Curves, Cubic Splines, , Bezier Curves, B-spline Curves, B-spline Curve Fit, B-spline Curve Subdivision, Parametric Cubic Curves, Quadric Surfaces. Bezier Surfaces. Fractal line and Surface Generation

Syllabus

Tutorial

List of Tutorials

1. Line Drawing and Circle Drawing.
2. Polygon filling algorithms.
3. Line clipping algorithm.
4. Polygon clipping algorithm.
5. 2D transformations
6. Applications of 2D transformations.
7. 3D transformations
8. Applications of 3D transformations
9. Hidden surface removal
10. Curves and fractals

Course Outcomes

Upon completion of the course, the graduates will be able to …

1. Understand computer graphics fundamentals
2. Utilize algorithms to draw, fill and perform clipping on various 2D objects.
3. Use mathematics to achieve 2D transformations on different 2D geometrical shapes
4. Systematically identify and solve numerical problems of 3D transformations and projections
5. Detect hidden surfaces and illumination models
6. Interpret the curves and fractals to represent graphics system.

Books and E-Resources

For Reference Print Book -

1. "Computer Graphics", D. Hearn, M. Baker, 2nd Edition, Pearson Education, 2002, ISBN 81-7808-794-4.

2. "Procedural Elements for Computer Graphics", D. Rogers, 2nd Edition, Tata McGraw-Hill Publication, 2001, ISBN 0-07-047371-4.

For Reference Electronic Book –

1. "Computer Graphics", S. Harrington, 2nd Edition, McGraw-Hill Publications, ISBN 0 - 07 -100472 -6.
2. "Computer Graphics Principles and Practice", J. Foley, V. Dam, S. Feiner, J. Hughes, 2nd Edition, Pearson Education, 2003, ISBN 81-7808-038-9.

For MOOCs and other learning Resources

https://www.coursera.org/courses?query=computer%20graphics

Multidisciplinary Minor

ITM004: Augmented Reality & Virtual Reality

Teaching Scheme:

Theory: 02 Hours / Week ;

Tutorial: 01 Hour / Week Total

Credits: 03

Syllabus

Theory

Unit 1: Introduction: Virtual Reality (VR) (04 Hours)

Introduction, Key Elements of VR, Experience, History, Applications. Augmented Reality (AR): Introduction, History, Key Aspects, and Applications

Unit 2: Interface to The Virtual World (05 Hours)

Input: User Monitoring, Position Tracking, Body Tracking, Physical input Devices, Speech Recognition (Audio Input) and World Monitoring: Persistent Virtual Worlds, Bringing the Real World into the Virtual World. Output: Visual Displays: Properties of Visual Displays, Monitor-based or Fishtank-VR, Projection-based VR, Head-based VR, See-through Head-based Displays, Handheld VR. Aural Displays: Properties of Aural Displays, Head-based Aural Displays- Headphones, Stationary Aural Displays- Speakers. Haptic Displays: Properties of Haptic Displays, Tactile Haptic Displays, End-effector Displays, Robotically Operated Shape Displays, Vestibular and Other Senses.

Unit 3: Representing And Rendering The Virtual World (05 Hours)

Representation of the Virtual World: Visual Representation in Virtual Reality, Aural Representation and Haptic Representation in Virtual Reality. Rendering Systems: Visual Rendering Systems: Visual Rendering Methods, Geometrically Based Rendering Systems, Nongeometric Rendering Systems, Rendering Complex Visual Scenes, Computer Graphics System Requirements. Aural Rendering Systems: Visual Rendering Methods, Rendering Complex Sounds, Sound Generation Hardware, Internal Computer Representation. Haptic Rendering Systems: Haptic Rendering Methods, Rendering Complex Haptic Scenes with Force Displays, Haptic Rendering Techniques

Unit 4: Interacting With The Virtual World And Virtual Reality Experience (05 Hours)

Interface Metaphors, Manipulating a Virtual World, Properties of Manipulation, Manipulation Operations, Navigating in a Virtual World-Way finding and Travelling, Classes of Travel Methods Interacting with Others-Shared Experience, Collaborative Interaction, Interacting with the VR System, Immersion, Rules of the Virtual World: Physics, Substance of the Virtual World.

Unit 5: Augmented Reality (04 Hours)

Concepts: Computer Graphics, Dimensionality, Depth Cues, Registration and Latency, Working of Augmented Reality, Augmented Reality Hardware (Sensors, Processors, Displays), Ingredients of an AR Experience.

Unit 6: Augmented Reality Software And Mobile Augmented Reality (05 Hours)

Write Unit details here; Write Unit details here; Write Unit details here; Write Unit details here; Write Unit details here; Write Unit details here

List of Tutorials

1. Explore AR/VR apps on mobile devices and discuss differences.
2. Set up Unity for AR/VR development.
3. Create a simple VR scene in Unity (e.g., a virtual room).
4. Build an AR marker-based app using Vuforia or AR Foundation.
5. Implement basic object manipulation (move, rotate, scale) in a VR app.
6. Add sound effects to an AR or VR scene.
7. Study a real AR/VR application (e.g., Google Maps AR or Hololens) and present a report.
8. Experiment with SLAM tracking using an AR SDK.
9. Develop a simple gesture-based interaction system in VR.
10. Discuss the impact of AR/VR on human health (e.g., VR sickness).

Course Outcomes

Upon completion of the course, student will be able to –

1. Understand the basics of Augmented and Virtual reality systems and list their applications
2. Describe interface to the Virtual World with the help of input and output devices
3. Explain representation and rendering system in the context of Virtual Reality
4. Analyze manipulation, navigation and interaction of elements in the virtual world
5. Summarize the basic concepts and hardware of Augmented Reality system
6. Create Mobile Augmented Reality using Augmented Reality techniques and software system.

Books and E-Resources

For Reference Print Book -

1. William R Sherman and Alan B Craig, "Understanding Virtual Reality: Interface, Application and Design", (The Morgan Kaufmann Series in Computer Graphics)", Morgan Kaufmann Publishers, San Francisco, CA, 2002
2. Alan B Craig, "Understanding Augmented Reality, Concepts and Applications", Morgan Kaufmann Publishers, ISBN:978-0240824086

For Reference Print Book –

1. Steven M. LaValle, "Virtual Reality", Cambridge University Press, 2016
2. Alan B Craig, William R Sherman and Jeffrey D Will, "Developing Virtual Reality Applications: Foundations of Effective Design", Morgan Kaufmann, 2009.
3. Schmalstieg / Hollerer, "Augmented Reality: Principles & Practice", Pearson Education India; First edition (12 October 2016),ISBN-10: 9332578494
4. SanniSiltanen, "Theory and applications of marker-based augmented reality", Julkaisija – Utgivare Publisher. 2012. ISBN 978-951-38-7449-0

For MOOCs and other learning Resources

1. https://nptel.ac.in/courses/106/106/106106138/
2. https://www.coursera.org/learn/introduction-virtual-reality
3. https://www.coursera.org/learn/ar
4. http://lavalle.pl/vr/book.html
5. https://www.vttresearch.com/sites/default/files/pdf/science/2012/S3.pdf

Multidisciplinary Minor

ITM005: Automated Software Testing

Teaching Scheme:

Theory: 02 Hours / Week ;

Tutorial: 01 Hour / Week Total

Credits: 03

Syllabus

Theory

Unit 1: Fundamentals of Software Testing and Quality Assurance - (4 Hours)

Introduction to Testing: Software Quality, What is Testing? Why is it needed (Objective) Differences: QA vs QC ,Principles of Software Testing, SDLC and STLC: Phases of SDLC, role of testing in each phase, comparison between SDLC and STLC, Verification and Validation, Software Testing Life Cycle (STLC) in Waterfall model, Software Testing Life Cycle (STLC) in Agile Methodology Error/Failure/Defect: Definitions with examples, defect injection and detection.

Unit 2: Test Process and Test Case Design Techniques - (4 Hours)

Test Process: Test Planning, Test Design, Test Execution, Defect Reporting, Test Closure activities. Test Case Design Techniques: Black-box techniques (Equivalence Partitioning, Boundary Value Analysis, Cause Effect Graphing, Decision Tables), White-box techniques (Statement, Branch, Condition, Path Coverage).

Unit 3: Types, Levels, and Approaches of Software Testing - (6 Hours)

Types and Levels of Testing: Unit, Integration, System, Acceptance, Regression, Alpha- Beta Testing. Testing Types by approaches: Static (GAP analysis) vs Dynamic Testing, Shift Left & Shift Right Testing, Exploratory Testing, Compatibility Testing, Usability testing, UX/UI testing, Interoperability testing, Multi Device testing (Mobile), Cross Browser testing. Testing Types by Objective: Functional Testing, Manual Testing. Automated Testing, Non-Functional Testing (NFT) Performance Testing, Security Testing ETL & Data Migration Testing.

Unit 4: Static and Dynamic Testing Techniques - (6 Hours)

Static Techniques: Reviews (Peer, Walkthrough, Inspection), Static Analysis Tools: Overview of static code analyzers, Code quality metrics. Dynamic Testing: Testing Strategies – Top-down, Bottom-up, Big Bang, Sandwich, Advantages, disadvantages, and use cases of each strategy, Integration Testing Techniques – Stubs and Drivers, Interface testing, Data flow between integrated modules.

Unit 5: Introduction to Selenium- (4 Hours)

Manual vs Automated Testing: Pros and Cons, Scope of Automation, Automation Testing Life Cycle,ROI of Test Automation, Introduction to Selenium, Components of Selenium IDE, RC, Grid, Web Driver, Web Driver Interface, Web Driver methods, Launch different browsers using Selenium, Introduction to Browser supported drivers, Introduction to Web Elements, Introduction to locator used to locate Web Elements.

Unit 6: Introduction to TestNG - (4 Hours)

Introduction to TestNG, Different annotation in TestNG, Introduction to testing .xml, Introduction to Annotation Sequence in TestNG, Different Parameters of @ Test annotation, Writing first pass test case, Writing fail test case, Groups in TestNG, Data Provider in TestNG

Syllabus
Tutorial

List of Tutorials:

1. Write a test plan and test cases for a simple calculator application (use Black-box techniques: EP and BVA).

2. Perform unit testing on basic functions (add, subtract, multiply, divide) in C++/Java.

3. Prepare decision tables for an online login system (valid/invalid username-password combinations).

4. Log and track at least 3 defects using JIRA

5. Conduct a code walkthrough of a given C++/Java program and prepare a defect log.

6. Automate login and form submission using Selenium WebDriver (Java/Python).

7. Develop data-driven test cases using TestNG or Pytest

8. Record & track bugs in JIRA from a failed automation run.

Course Outcomes

Students will be able to:

- CO1: Understand and evaluate test automation principles and frameworks.
- CO2: Develop, execute, and maintain automated scripts using industry tools.
- CO3: Integrate automation into CI/CD pipelines effectively.
- CO4: Manage and log defects efficiently using standard tools.
- CO5: Apply automation for API, UI, and regression testing scenarios.
- CO6: Interpret test metrics and improve testing effectiveness.

Books and E-Resources

For Reference Print Book -

- P. Jorgensen; Software Testing: A Craftsman's Approach; 4th Edition; CRC Press; 2013
- G. J. Myers, C. Sandler, T. Badgett; The Art of Software Testing; 3rd Edition; Wiley; 2011

- Srinivasan Desikan & Gopalaswamy Ramesh, *Software Testing: Principles and Practices* Pearson Education, ISBN: 9788177581218
- Boris Beizer, *Software Testing Techniques* (2nd Edition) Dreamtech Press, ISBN: 9788177222609
- Rex Black, Erik van Veenendaal, Dorothy Graham, *Foundations of Software Testing: ISTQB Certification* Cengage Learning, ISBN: 9788131526366
- Ron Patton, *Software Testing* (2nd Edition) Sams Publishing, ISBN: 9788131708984

For Reference Electronic Book –

• R. Black; *Managing the Testing Process*: Practical *Tools and Techniques for Managing Hardware and Software Testing*; 3rd Edition; Wiley; 2009; Accessed: May 16, 2025; [Online]. Available: https://ebookcentral.proquest.com/lib/xyz/detail.action?docID=469921

• L. Copeland; *A Practitioner's Guide to Software Test Design*; Artech House; 2004; Accessed: May 16, 2025; [Online]. Available: https://ebookcentral.proquest.com/lib/xyz/detail.action?docID=203342

For MOOCs and other learning Resources

- T. Koskela; *Software Testing and Automation Specialization*; Coursera; https://www.coursera.org/specializations/software-testing-automation; Accessed: May 16, 2025
- A. Kaner; *Black Box Software Testing*; BBST; https://bbst.courses; Accessed: May 16, 2025
- Course: *Software Testing* by Prof. Rajib Mall (IIT Kharagpur) , Link: https://nptel.ac.in/courses/106105150

Multidisciplinary Minor

ITM006: Management Information Systems

Teaching Scheme:

Theory: 02 Hours / Week ;

Tutorial: 01 Hour / Week Total

Credits: 03

Syllabus Theory

Unit 1: **Introduction to MIS** - (5 Hours)

Definition, need, and importance of MIS, Components of MIS, Role of MIS in organizations, MIS vs. IT vs. ERP, Systems approach to MIS

Unit 2: **Types of Information Systems** - (5 Hours)

Transaction Processing Systems (TPS), Management Information Systems (MIS), Decision Support Systems (DSS), Executive Support Systems (ESS), Enterprise systems (ERP, SCM, CRM)

Unit 3: **Information Systems and Decision Making** - (4 Hours)

MIS for operational, tactical, and strategic decision making, Structured vs. unstructured decisions, Role of MIS in problem identification and solution generation, Case studies on MIS applications in various sectors

Unit 4: **Development and Implementation of MIS** - (5 Hours)

System Development Life Cycle (SDLC), Prototyping and agile methodologies, Feasibility study and requirement analysis, Change management and implementation challenges, User involvement and training

Unit 5: **Strategic Role of Information Systems** - (5 Hours)

IT for competitive advantage, Business process reengineering and MIS, Digital transformation and e-Business models, Case studies on strategic use of MIS

Unit 6 **Security, Ethics, and Emerging Trends** - (4 Hours)

Information security: threats, vulnerabilities, and controls, Ethical and social issues in MIS, Legal aspects and data privacy, Cloud computing, AI in MIS, Big Data Analytics, Globalization and MIS in international business

Syllabus
Tutorials

List of Tutorials

1. Prepare a short case study analysis showing how a real company uses MIS in its operations (e.g., Amazon, Walmart, Zomato).
2. Create a comparison table between TPS, MIS, DSS, and EIS with real-life examples.
3. Analyze a managerial decision problem and describe how MIS could support it (e.g., product pricing, hiring strategy).
4. Design a basic SDLC chart for developing an MIS for a retail store
5. Research and write a short report on how a company (e.g., Netflix, Uber) uses MIS as a competitive tool.
6. Identify a recent data breach incident and analyze the MIS-related vulnerabilities involved.
7. Hands-On with Microsoft Access or MySQL, Creating forms, queries, and reports
8. Dashboard Creation Using Excel or Power BI, Visualizing KPIs, Connecting to databases
9. Mini Project: MIS for a Small Business Simulate MIS design, DB creation, and reporting
10. Digital Transformation and E-Business, E-commerce models (B2B, B2C, C2C)

Books and E-Resources

For Reference Print Book -

1. **James A. O'Brien & George M. Marakas**, *Management Information Systems*, 10th Edition, McGraw-Hill Education.

For Reference Electronic Book –

Kenneth C. Laudon & Jane P. Laudon, *Management Information Systems: Managing the Digital Firm*, 16th Edition, Pearson Education

For MOOCs and other learning Resources

Bansilal Ramnath Agarwal Charitable Trust's

VISHWAKARMA INSTITUTE OF TECHNOLOGY, PUNE – 37

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

Department of Mechanical Engineering

Multidisciplinary Minor (MDM)

Second Year - AY 2025-26

1. **MEM001: Digital Crafting Techniques**
2. **MEM002: Product Design and Development**
3. **MEM003: Automobile Systems**
4. **MEM004: Thermal Systems**
5. **MEM005: Power Plant Engineering**

Multidisciplinary Minor

MEM001: Digital Crafting Techniques

Teaching Scheme:

Theory: 02 Hours / Week, Tutorial: 01 Hours / Week

Total Credits: 03

Unit 1: Digital Crafting Fundamentals - (06 Hours)
Definition, scope, and evolution from traditional to digital fabrication. Role of makerspaces, fab labs, and collaborative workspaces in modern prototyping. Digital Fabrication Tools Overview. 3D Printers (FDM, SLA, SLS), CNC machines, laser cutters, plotters, and vinyl cutters. Safety & Lab Practices.
Digital Design Principles, Parametric vs. non-parametric modelling. 2D/3D modelling software. File Formats & Interoperability **(**STL, DXF, OBJ, G-code). Generative & Algorithmic Design.

Unit 2:3D Printing Technologies & Workflow - (08 Hours)
Additive Manufacturing (AM) Principles, Layer-by-layer fabrication vs. traditional manufacturing, Types of 3D Printing (FDM, SLA, SLS etc). From design to print workflow. Model preparation & manoeuvring, Slicing software **(**settings, infill patterns, rafts, and brims).
Materials & Process Parameters- Thermoplastics (PLA, ABS, PETG), resins, composites, metals – properties and applications. Key Parameters**-** Layer height, nozzle temperature, print speed, cooling – impact on strength and surface finish. Troubleshooting & post-processing. Applications of 3D Printing.

Unit 3: Subtractive & hybrid manufacturing for smart prototypes - (07 Hours)
Subtractive Manufacturing Techniques- CNC cutting, laser cutting & engraving, waterjet Cutting. Materials for Subtractive Processes, Hybrid Manufacturing Systems, Combining 3D printing with CNC machining for complex geometries.
Post-processing techniques (drilling, tapping, surface finishing), Design for Manufacturing (DFM), Tolerances, support structures, and minimizing material waste.

Unit 4: **Electronics Integration & Smart Prototyping** - (07 Hours)
Embedded Electronics Basics- Microcontrollers, Sensors & Actuators, PCB Design & Fabrication techniques. IoT & Wireless Prototyping, Wi-Fi (ESP8266/ESP32), Bluetooth, LoRa for smart devices. Cloud integration (MQTT, Node-RED).
Smart Prototyping Applications, Wearable tech, home automation, robotic systems. Case studies: 3D-printed drones, IoT-enabled environmental sensors.

Tutorials

List of Tutorials

1) Introduction to Makerspaces and Digital Fabrication Tools
2) 2D and 3D CAD modelling basics
3) Parametric Design with Constraints
4) Slicing and Preparing Models for 3D Printing
5) 3D Printing workflow
6) Troubleshooting print quality issues
7) Hybrid Prototyping Project
8) Embedding Electronics into Prototypes
9) Smart System Integration
10) AI-Assisted Generative Design (Fusion 360 + Autodesk Generative Design)

Course Outcomes

1. Describe the principles of digital fabrication and its tools
2. Develop2D and 3D CAD models using parametric design principles
3. Demonstrate proficiency in slicing, calibrating, and operating for 3D printers.
4. Analyse the influence of process parameters and material selection on print quality and mechanical performance.
5. Apply subtractive and hybrid manufacturing techniques using laser cutters and CNC tools
6. Design and fabricate a working prototype by integrating CAD models, 3D printing, subtractive processes, and basic electronics (microcontrollers and sensors).

Books and E-Resources

For Reference Print Book -

1) Debasis Bagchi, Introduction to 3D Printing and Design,
2) Chua Chee Kai, K. F. Leong, and C. S. Lim, Rapid Prototyping: Principles and Applications
3) Amit Bandyopadhyay &Susmita Bose, Additive Manufacturing
4) Rajesh Singh, Anita Gehlot, Arduino: A Technical Reference

For Reference Electronic Book –

1) Ian Gibson, David Rosen, Brent Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing
2) Massimo Banzi and Michael Shiloh, Getting Started with Arduino
3) S. Shanmugam, Mechatronics: Principles, Concepts and Applications

For MOOCs and other learning Resources

1) Digital Fabrication & Makerspaces-https://www.coursera.org/learn/digital-fabrication
2) CAD & 3D Modeling-https://www.udemy.com/course/autodesk-fusion-360-for-beginners/
3) 3D Printing & Slicing-https://www.coursera.org/learn/additive-manufacturing
4) Electronics & IoT Prototyping-https://www.coursera.org/learn/arduino-platform

Multidisciplinary Minor

MEM002: Product Design and Development

Teaching Scheme:

Theory: 2 Hours / Week Tutorial: 01 Hours / Week

Total Credits: 3

Unit-I (5hrs)

Definition of product design, Essential Factors for product design, Modern approaches to product design, Characteristics of Successful Product Development, Innovative Thinking, Challenges to Product Development, product development versus product design.

Unit-II (5hrs)

Technical Questioning, Technology Forecasting and S Curve, Customer Needs and Satisfaction, Types of customer need, Customer need model, Tools for gathering Customer Needs.

Unit-III (5hrs)

Product development process- Identification of customer needs- customer requirements, product development process flows, Product specifications, concept development and concept generation, concept selection, concept screening, concept scoring, concept testing.

Unit-IV (5hrs)

Introduction of reverse engineering, Product Teardown Process, Tear Down Methods, Force Flow Diagrams, Measurement and Experimentation, Applications of Product Teardown, Benchmarking Approach and Detailed Procedure, Tools Used in Benchmarking.

Unit-V (5hrs)

Design for manufacture, Design for assembly, Design for robustness, Design for safety, Design for reliability, Design for environment, Design for piece part production, manufacturing cost analysis. Local, Regional and Global issues, basic life cycle assessment - basic method, Design Failure mode effect analysis.

Unit-VI (5hrs)

Industrial Design, Design thinking, ergonomics, sustainable design, design management

Tutorials

List of Tutorials

1. Design of concept of Innovative product.
2. Development of concept of Innovative product using any modelling software.
3. Development of standard process for gathering customer needs related to new product.
4. Prepare product development process flows for new innovative product.
5. Prepare Case study for application of reverse engineering technique using benchmarking of product.
6. Prepare Case study for application of design for manufacturing and assembly.
7. Prepare Case study for application of design for safety.
8. Prepare Case study for application of design for Environment.
9. Use of AI generative tool for obtaining optimum solution
10. Case studies on Industrial product development
11. Case studies on Design for X

Course Outcomes

The student will be able to –

Course Outcomes: Upon completion of the course, students will be able to

1. Design product as per customer needs and satisfaction.
2. Apply engineering, scientific, and mathematical principles to execute a design from concept to finished product.
3. Analyse methods and processes of Forward and Reverse engineering
4. Analyse methods of Design for manufacturing and analysis.
5. Understand particular phases of product development
6. Apply DFX principles in designing engineering component or product

Books and E-Resources

For Reference Print Book -

Text Books:

1.Product Design-Techniques in Reverse Engineering and New Product Development, Kevin Otto, Kristion Wood, Pearson Education, ISBN 978-81-7758-821-7.

2. Karl T.U. And Steven D.E., Product Design and Development, McGraw Hill, Ed 2000

3. K. Chitale; R.C. Gupta, Product Design and Manufacturing, Prentice Hall India.

4. David G Ullman, "The Mechanical Design Process", McGraw Hill Pub. Co. Ltd., Delhi.
5. George E Dieter, Linda C Schmidt, "Engineering Design", McGraw Hill Pub. Co. Ltd., Delhi.

Reference Books:

1. Spotts M. F. and Shoup T. E. "Design of Machine Elements", Pearson Education Pvt. Ltd., Delhi.
2. Shigley J. E. and Mischke C. R, "Mechanical Engineering Design', 6th international Edition, McGraw Hill Pub. Co. Ltd., Delhi.
3. William Orthwein. Machine Component Design, Jaico Publication. Mumbai.
4. "Design Data", P.S.G. College of Technology, Coimbatore

Multidisciplinary Minor

MEM003: Automobile Systems

Teaching Scheme:
Theory: 2 Hours / Week; Tutorial: 1 Hours / Week Total
Credits: (3)

Unit 1: Basic Concepts and Clutches (5 Hours)
Engine components, basic engine nomenclature, engine classification, working of four stroke & two stroke engines, Vehicle specifications, classification, layout, applications, Purpose of clutch, classification, single plate clutch, multiple plate clutch, centrifugal clutch, cone clutch, diaphragm spring clutch, vacuum operated clutch, clutch plate, lining material

Unit 2: Gearbox (5 Hours)
Function, various resistances, tractive effort, performance curves, sliding mesh gearbox, constant mesh gearbox and synchromesh gearbox, epicyclic gearbox, torque convertor, automatic transmission, overdrive.

Unit 3: Steering System (5 Hours)
Purpose, requirement, steering mechanisms, wheel alignment and wheel Balancing, centre point steering, cornering force, slip angle, scrub radius, reference frame, toe-in, toe-out, wheel camber, caster and kingpin angle, steering offset, steering Characteristic, steering gearboxes, power steering.

Unit 4: Power Transmitting Systems (5 Hours)
Propeller shaft, universal joints, final drive, differential and their types, rear axle arrangements, two speed rear axles, single, double and triple reduction rear axles. Driving thrust, torque reaction, Hotchkiss drive, Torque tube drive

Unit 5: Suspension System and Braking System (5 Hours)
Object, various types of springs, shock absorbers, sprung weight and un-sprung weight, basic suspension movements, conventional suspension system, independent suspension systems, air suspension, hydro elasticity suspension, hydra-gas suspension, interconnected suspension, self-levelling suspension.
Braking System- Purpose, stopping distance and time, braking force, brake efficiency, classification, mechanical, hydraulic, air brakes, antiskid braking system.

Unit 6: HEV and Battery Packs (5 Hours)
Difference between Conventional vehicles and EV power trains, Types of Hybrid Vehicles, Topologies, Types of EV batteries and battery pack, battery pack selection and design

Tutorials

List of Tutorials

1. Study of vehicle Layout with all components Practically
2. Design of Conventional Drive Train using MATLAB/Simulink
3. Design of Ackerman Steering Gear Mechanism using CATIA V5
4. A comparative study of two common driveline systems used in rear-wheel-drive vehicles.
5. Study on Vehicle Stability and Control
6. Study of Electrical and Hybrid Vehicle Layout
7. Study of Battery Components of Li-ion Battery
8. Design and Analysis of Li-Ion Battery Discharge Circuit
9. Design of EV Power Train Using MATLAB/Simulink
10. Visit to any Industry or Auto Expo

Course Outcomes

1. Understand and analyse engine types, vehicle classifications and layouts, and explain the construction, working, and applications of various clutch systems and components.
2. To know the function of a gearbox and analyse vehicle resistances and performance and working of various manual Automatic transmission.
3. Understand the purpose and components of steering systems and analyse steering geometry.
4. Remember function of power transmitting devices in an automobile system.
5. Understand the function of suspension and braking system.
6. To know various components of Hybrid and Electric vehicles.

Books and E-Resources

For Reference Print Book -

1. K.Newton, W.Steeds&T.K.Garrett, 'The Motor Vehicle', 'BUTTERWORTHS' London.
2. Singh Kripal, 'Automobile Engineering', Vol.I and Vol. II, Standard Publishers Distributors.
3. R.K. Rajput, A Textbook of Automobile Engineering,Laxmi Publications (Pvt.) Ltd.

For Reference Electronic Book –

1. Automotive Engineering: Power train, Chassis System and Vehicle Body Edited By David A. Crolla.
2. Major Systems and Components of an Automobile by NCERT.
3. Basic Automobile Engineering Theory & Practical By Byjus.
4. Automotive Engineering Fundamentals by Richard Stone and Jeffrey K. Ball.
5. Vehicle Dynamics and Control by Rajesh Rajmani.
6. AA Book of Car. Available: https://ebookcentral.proquest.com

For MOOCs and other learning Resources

1. Fundamentals of Automotive Systems By Prof. C. S. Shankar Ram | IIT Madras https://onlinecourses.nptel.ac.in/noc20_de06/preview
2. Automotive Engineering: Automobile Systems and Components by Udemy : https://www.udemy.com/course/automotive-engineering-automobile-systems-andcomponents/?srsltid=AfmBOopNZgzvBvZkuFPIROGS5N37_nBhURDzkOlGiy-Pgp_E3EWYMoFA&couponCode=CP130525.
3. https://www.coursera.org/learn/automotive-industrial-engineering

Multidisciplinary Minor

MEM004: Thermal Systems

Teaching Scheme:

Theory: 02. Hours / Week; Laboratory: 00 Hours / Week; Tutorial: 01 Hours / Week

Total Credits: (03)

Unit 1: Boiler (06 Hours)

Classification of boiler, Boiler mounting and accessories, Boiler draught (natural and artificial draught) Boiler performance calculations-Equivalent evaporation, Boiler efficiency Energy balance.

Unit 2: Refrigerator & Air conditioning (06 Hours)

Working of refrigerator, Vapour compressor cycle. Working of split air conditioning. Properties of dry and wet air, use of psychrometric chart, processes involving heating/coolingand humidification/dehumidification, concept of dew point.

Unit 3: Compressor (06 Hours)

Reciprocating compressors, staging of reciprocating compressors, optimal stage pressure ratio, effect of intercooling, minimum work for multistage reciprocating compressors.

Classification of compressors, Construction, velocity diagram, flow process on T-S Diagram,

Unit 4: Internal combustion engines (06 Hours)

Classification of I C Engines, Components of Engines, two stroke and four stroke engines, Petrol engine, Diesel engine, Alternative fuel, Hybrid engines and comparison. Introduction to soft tools for I C Engines.

Tutorial

List of Tutorials

1. Determination of theoretical COP of refrigeration system.
2. Performance of boiler
3. Demonstration of internal combustion engine
4. Demonstration of Psychrometric processes.
6. Determination of performance of air Nozzles.
7. Performance test on reciprocating air compressor.
8. Study and trial on centrifugal air compressor and plotting its characteristics

List of Books:

1. Y. Cengel& Boles: Thermodynamics – An Engineering Approach, Tata McGraw HillPublications
2. R. K. Rajput, Engineering Thermodynamics, EVSS Thermo Laxmi Publications
3. P. L Ballany: Thermal Engineering, Khanna Publishers
4. C.P. Arora: Engineering Thermodynamics, Tata McGraw Hill Publications

Course Outcomes

At the end of the course the students will be able to.

1. Understand the different industrial boilers
2. Understand the working of refrigerator and air conditioning system
3. Know functioning of reciprocating and centrifugal compressor
4. Understand working of internal combustion engine

Multidisciplinary Minor

MEM005: Power Plant Engineering

Teaching Scheme:

Theory: 02. Hours / Week

Tutorial: 01 Hours / Week

Total Credits: (03)

Unit 1: Fundamental of Power plant: (2Hours)

Present Indian & Global scenario of demand and supply of conventional power plant with respect to available resources. Overview of Power generating plants- Govt. and Private corporations in India with including power generating capacity. Introduction to power plants, Concept their importance.

Unit 2: - Thermal and Hydroelectric power plant: (6Hours)

Role of thermal power plant in current power generation scenario, Selection site for thermal power plant, General lay out of a thermal power plant, Fuels used in thermal power plant, Layout, Equipment and working of a typical thermal power plant.

Introduction to Hydroelectric power plant, Selection of sites for hydroelectric power plant, classification, general layout of hydroelectric power plant and components, Principle, Construction and working, Types of turbines, Hydro power plants with capacity in Maharashtra.

Unit 3: Diesel and Gas Power Plant - (4 Hours)

Advantage and limitations, types of diesel plants, general layout, and applications. Components of gas power plant, gas turbine, fuels, materials, working and applications.

Unit 4: Biomass Energy:(4 Hours)

Introduction, Biomass conversion technologies, Biogas generation, classification of biogas plants and their Operating system. Biomass as a source of energy, methods of obtaining energy from biomass, thermal gasification of biomass, Applications.

Unit 5: - Nuclear power plant: (6 Hours)

Criteria for selection of installation of nuclear power plant, Energy conversion process, Layout and working of a typical nuclear power plant, Equipment used in nuclear power

plants and their function only, Nuclear power plants with capacity at national and state level , advantages and disadvantages.

Unit 6: Renewable power plants - (6 Hours)

Solar power generation – Photo-voltaic and solar thermal generation – solar concentrators,

Wind power generation – types of windmills, wind generators, tidal, geothermal and magneto hydro dynamic power generation, Major Solar power plants with capacity at national and state level.

List of Tutorials

1 Collect the information for battery suitable for solar storage system.

2) Visit/observe video clips of Solar based vehicle charging system and write report on it.

3) Visit the site to observe Solar PV system installation and write report on it.

4) Observe video clips to study gear box system use in wind power plant.

5) Prepared report for step-by-step procedures to be followed for developing wind power plant.

6) Visit the biogas plant and collect details of all components and biogas generation. Write report on it

7) Collect information details of existing ocean power plants.

8) Prepare a detailed report on hydrogen energy.

9) Detailed report on information about potential geothermal energy and tidal energy in India.

10) Write a report on Jawaharlal Nehru National Solar Mission (JNNSM).

11) Survey on solar applications.

12 Blog on renewable energy and environmental effects.

13) Case study on any large wind power plant.

14) To study the layout of a Thermal Power Plant with its components.

15) To Visit a Thermal Power plant and write a technical report on the observations

16) To Visit a Hydroelectric Power plant and write a technical report on the observations.

17) Selection of sight of Hydro Power Plant

18) Environmental impact of Thermal Power Plant.

19) Waste Disposal of Nuclear Power Plants

20) Cooling water requirements for power plant and water pollution

21) Solar energy as a clean energy source.

22)Study of Fundamentals of wind energy

23)Study of Horizontal Axis Wind Turbine.

Course Outcomes: On completion of the course, students will be able to –

1) **Describe and analyse** different types of sources and mathematical expressions related to thermodynamics and various terms and factors involved with power plant operation.

2) **Describe** the power generation scenario, the layout components of thermal power plant and analyse the improved Rankin cycle, Cogeneration cycle.

3) **Analyse** the steam condensers, recognize the environmental impacts of thermal power plant and methods to control the same.

4) **Recognize** the layout, component details of hydroelectric power plant and nuclear power plant.

5) **Realize** the details of diesel power plant, gas power plant and analyse gas turbine power cycle.

6) **Emphasize** the fundamentals of non-conventional power plants.

Books and E-Resources

Text Books:

1. Domkundwar & Arora, Power Plant Engineering, DhanpatRai& Sons, New Delhi

2. Domkundwar & Domkundwar- Solar Energy and Non-Conventional Sources of Energy, DhanpatRai& Sons, New Delhi.

3. R.K.Rajput, Power Plant Engineering‖, Laxmi Publications New Delhi.

4. D.K.Chavan&G.K.Phatak, Power Plant Engineering‖, Standard Book House, New Delhi.

References Books:

1. E.I.Wakil, Power Plant Engineering‖, McGraw Hill Publications New Delhi

2. P.K.Nag, Power Plant Engineering‖, McGraw Hill Publications New Delhi.

3. R.Yadav , Steam and Gas Turbines‖ ,Central Publishing House, Allahabad.

4. G.D.Rai, Non-Conventional Energy Sources, KhannaPublishers,Delhi

5. S.P.Sukhatme, Solar Energy‖ Tata McGraw-Hill Publications, New Delhi

6. G R Nagpal Power Plant Engineering ,Khanna Publication

7. Gas Turbines by V.Ganeshan, McGraw Hill Education

8. Steam Turbine Theory and Practice, William J. Kearton, CBS Publication

9. Power plant Engg / Elanchezhian/ I.K. International Pub

Moocs Links and additional reading material: www.nptelvideos.in

1. http://nptel.ac.in/courses/108105058/8

2. http://nptel.ac.in/courses/108105058/9

3. http://nptel.ac.in/courses/108105058/10