



## Department of Electronics and Communication Engineering

### Ph.D. Course Work

(Applicable for the scholars admitted from the AY: 2025-26)

The credit requirement for the Ph.D. course work is a minimum of 12 credits including the courses on ‘Research Methodology’ and ‘Research and Publication Ethics’ for 2 credits each. The candidate must complete two domain-specific courses of 3 credits each, recommended by the respective Department Research Committee (DRC). These courses can be completed through MOOCs.

The candidate must present two research seminars before the completion of course work, typically within the first year. The first research seminar shall be before the end of first semester on introduction to the proposed research work, and the second seminar shall be before the end of the second semester or after the completion of course work on the research proposal, as per the format provided. Each research seminar will have one credit weightage. The course structure is presented in Table 1 and list of domain-specific courses is presented in Table 2.

**Table 1: Course Structure**

S.No.	Course Code	Name of the Course	Credit (s)
1	2517UC01	Research Seminar –I	1
2	2517UC02	Research Seminar –II	1
3	2517UC03	Research Methodology	2
4	2517UC04	Research and Publication Ethics	2
5	-	Domain Specific Course –I	3
6	-	Domain Specific Course –II	3
<b>Total</b>			<b>12</b>

**Table 2: List of Domain-Specific Courses**

S. No.	Course Code	Name of the Course
1	2517EC01	Modern Antenna Theory & Design
2	2517EC02	Radiating Elements, Analysis and Measurements
3	2517EC03	Antenna Measurements
4	2517EC04	Design Principles of Microwave Antennas
5	2517EC05	Fundamentals of Semiconductor Fabrication Technology
6	2517EC06	Design and Analysis of VLSI subsystems
7	2517EC07	Sensors and Actuators
8	2517EC08	Computer Vision and Image Processing: fundamentals and Applications
9	2517EC09	Multimedia and Signal Coding
10	2517EC10	Applied Linear Algebra and Optimization for ML Based WC
11	2517EC11	Deep Learning
12	2517EC12	Signal Transform Techniques
13	2517EC13	Speech Signal Processing
14	2517EC14	Bio Medical Signal Processing
15	2517EC15	Modern Mobile Communication Systems
16	2517EC16	Mobile Computing Technologies
17	2517EC17	Advanced Wireless Networks
18	2517EC18	Advanced 5G Wireless Communication
19	2517EC19	Embedded System Design with ARM
20	2517EC20	Embedded Networking
21	2517EC21	Computer Vision

## Research Methodology

**Course Code: 2517UC03**

### **UNIT -I:**

#### **Research Design**

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Case studies.

### **UNIT-II:**

#### **Data Collection and Sources**

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

### **UNIT-III:**

#### **Data Analysis and Reporting**

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

### **UNIT-IV:**

#### **Intellectual Property Rights**

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

### **UNIT-V: Patents**

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

### **Text Books:**

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Sage Publications, 4<sup>th</sup> Edition, 2015.
2. Intellectual Property: A Very Short Introduction, Siva Vaidhyanathan, Oxford University Press, 2017.
3. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" Deborah E. Bouchoux, Cengage India, 4<sup>th</sup> Edition, 2013.

### **Reference Books:**

1. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard, Juta Academic, 2<sup>nd</sup> Edition, 2014.
2. Research design: Qualitative, quantitative, and mixed methods approaches, Creswell, J.W. and Creswell, J.D., Sage publications, 2017.
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, Clause 8 Publishing; Volume I: Perspectives, Trade Secrets & Patents; 2023.

**Weblinks:**

1. <https://archive.nptel.ac.in/courses/121/106/121106007/#>
2. [https://onlinecourses.swayam2.ac.in/ntr24\\_ed08/preview](https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview)

## **Research and Publication Ethics**

**Course Code: 2517UC04**

### **UNIT-I:**

#### **Philosophy & Ethics**

##### **Introduction to Philosophy:**

Definition, Nature & Scope, Concept, Branches

**Ethics:** Definition, Moral Philosophy, Nature of Moral Judgements & Reactions

### **UNIT-II:**

#### **Scientific Conducts**

Ethics with respect to Science and Research, Intellectual Honesty & Research Integrity

##### **Scientific Misconducts:**

Falsification, Fabrication & Plagiarism

##### **Redundant Publications:**

Duplicate & Overlapping Publication, Salami Slicing, Selective Reporting & Misrepresentation of Data

### **UNIT-III:**

#### **Publication Ethics:**

Definition, Introduction and Importance

##### **Best Practices/ Standard Setting Initiatives and Guidelines:**

COPE, WAVE, etc., Conflicts of Interest

##### **Publication Misconduct:**

Definition, Concept, Problems that lead to unethical behaviour and vice-versa, types, Violation of Publication Ethics, Authorship and Contributorship, Identification of Publication Misconduct, Complaints and Appeals, Predatory Publishers and Journals

### **UNIT-IV:**

#### **Open Access Publishing**

Open Access publications and Initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-achieving policies, Software tool to identify predatory publications developed by SPPU, Journal Finder/ Journal Suggestion tools viz. JANE, ELSEVIER, SPINGER, Journal suggester etc.

### **UNIT-V:**

#### **Publication Misconduct**

##### **Group Discussions:**

Subject-specific Ethical issues, FFP, Authorship, Conflicts of Interest, Complaints and Appeals: Examples and fraud from India and Abroad

##### **Software tools:**

Use of Plagiarism software like Turnitin, Urkund and other open source software tools

### **Unit-VI:**

#### **Database and Research Metrics**

##### **Database:**

Indexing database, Citation database: web of science, Scopus etc.

Impact factor of journal as per journal citation report, SNIP, SJR, IPP, cite score

**Metrics:**

h-index, g-index, i-10 index, AL metrics etc.

**Text Books:**

1. Philosophy in Science, Bird A, Routledge, 2006.
2. A Short History of Ethics, MacIntyre, London, 1967.

**Reference Book:**

1. Ethics in Science, Education and Governance, Indian National Science Academy, 2019.

**Weblinks:**

1. [www.niehs.nih.gov/research/resources/bioethics/whatis](http://www.niehs.nih.gov/research/resources/bioethics/whatis)
2. [https://onlinecourses.swayam2.ac.in/nou22\\_ge73/preview](https://onlinecourses.swayam2.ac.in/nou22_ge73/preview)

## Modern Antenna Theory & Design

**Course Code: 2517EC01**

### **UNIT-I:**

#### **Radiation mechanism of Antenna**

Fundamental concepts of radiation and antenna parameters, radiation from wires and loops: infinitesimal dipole, finite length dipole, radiation from rectangular and circular apertures, Radiation from sectoral and pyramidal horns, design concepts.

### **UNIT-II:**

#### **Microstrip antenna**

Basic characteristics of microstrip antennas, types, feeding methods, methods of analysis, design of rectangular and circular patch antennas, Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension to planar arrays.

### **UNIT-III:**

#### **Meta material for antenna application**

Introduction to meta materials: definition and properties of meta materials, wave propagation in left-handed media, energy density and group velocity, negative refraction, Fermat principle, other effects in left-handed media, meta material based electrically small antennas, efficiency, Q factor., application of meta material in leaky wave antennas, time domain analysis and studies of various UWB antennas with and without meta material loading.

### **UNIT-IV:**

#### **Reconfigurable antennas**

Classification of reconfigurable antennas, reconfiguration techniques, implications for reconfigurable antennas, methods for achieving reconfigurability (frequency, polarization, and pattern), compound reconfigurable antennas, comparison, practical issues for implementing reconfigurable antennas, reconfigurable antennas for cognitive radio and 5G applications.

### **UNIT-V:**

#### **Smart antenna and beam forming techniques**

Smart Antenna: Introduction, need for smart antennas, smart antenna configurations and architecture of a smart antenna system, benefits and drawbacks of smart antennas, fundamentals of DOA and antenna beam forming.

### **Text Books:**

1. Microstrip Antenna Design Handbook, Garg, R., Bhartia, P., Bahl, I. and Ittipiboon, A. Artech House 2001. ISBN-10 0890065136-
2. Antenna Theory and Design, Balanis, C.A. 3rd Ed., John Wiley & Sons, 2005. ISBN: 9781118585733, 1118585739

**Reference Books:**

1. Reconfigurable Antennas, Jennifer T. Bernhard, Morgan & Claypool 2007, ISBN: 9781598290264, 1598290266.
2. Introduction to Smart Antennas, Constantine A. Balanis, Morgan & Claypool 2007 ISBN: 9781598291766, 1598291769.

**Weblinks:**

1. <https://nptel.ac.in/courses/117107035>
2. <https://nptel.ac.in/courses/108101092>

## **Radiating Elements, Analysis and Measurements**

**Course Code: 2517EC02**

### **UNIT-I:**

#### **Fundamentals of Antenna**

Basics Concepts of Radiation: Radiation from surface current and current line current distribution, Basic antenna parameters, Radiation Mechanism-Current distribution of Antennas, Impedance Concept-Balanced to Unbalanced transformer.

### **UNIT-II:**

#### **Horn, Reflector and Slot antennas**

Radiation from Apertures Field equivalence principle, Rectangular and circular apertures, Uniform distribution on an infinite ground plane, Aperture fields of Horn antenna-Babinet's principle, Geometrical theory of diffraction, Reflector antennas, and Design considerations - Slot antennas.

### **UNIT-III:**

#### **Antenna Arrays**

Synthesis of Array Antennas Types of linear arrays, current distribution in linear arrays, Phased arrays, Optimization of Array patterns, Continuous aperture sources, Antenna synthesis techniques.

### **UNIT-IV:**

#### **Broadband Antennas**

Biconical Antenna, Triangular Sheet, Flexible and Conformal Bow-Tie, Vivaldi Antenna, Discone and Conical Skirt Monopole. Frequency Independent Antennas Spiral Antennas, Log-Periodic Antennas.

### **UNIT-V:**

#### **Antenna Measurements**

EMI/EMC/Antenna Measurements: Log periodic, Bi-conical, log spiral ridge Guide, Multi turn loop, Travelling Wave antenna, Antenna measurement and instrumentation, Amplitude and Phase measurement, Gain, Directivity, Impedance and polarization measurement, Antenna range, Design and Evaluation.

#### **Text Books:**

1. Microstrip Antenna Design Handbook ,Garg, R., Bhartia, P., Bahl, I. and Ittipiboon, A.ArtechHouse 2001. ISBN-10 0890065136-
2. Antenna Theory and Design ,Balanis,C.A.3rdEd.,JohnWiley&Sons,2005. ISBN:9781118585733, 1118585739

#### **Reference Books:**

1. Reconfigurable Antennas, Jennifer T.Bernhard, Morgan& Claypool2007, ISBN: 9781598290264, 1598290266.
2. Introduction to Smart Antennas ,Constantine A. Balanis, Morgan& Claypool2007 ISBN:9781598291766, 1598291769.

#### **Weblinks:**

1. <https://nptel.ac.in/courses/108105114>
2. <https://nptel.ac.in/courses/108101092>

## **Antenna Measurements**

**Course Code: 2517EC03**

### **UNIT-I:**

#### **Antenna Pattern Measurements**

Basic Considerations, Pattern Formats, Fresnel Region Measurements, Modelling Techniques.

### **UNIT-II:**

#### **Antenna Range Design and Evaluation**

Introduction, Electromagnetic Design Consideration, Antenna Range Evaluation.

### **UNIT-III:**

#### **Antenna Testing: Introduction, Types of Ranges**

Elevated Ranges, Ground Ranges, Near Field Ranges, Radar Cross Section Ranges.

Far Field Range Design: Introduction, Designing the Range, Source Design, Receiving Site Design, Ground Ranges.

### **UNIT-IV:**

#### **Far Field Antenna Tests**

Introduction, Pattern Testing, Gain and Directivity, Polarization. Far Field Pattern Errors: Introduction, Error Estimates, Error Correction, Antenna Errors.

### **UNIT-V:**

#### **Compact Ranges**

Introduction, Room Design, Feed Design, Reflector Design.

Near Filed Testing: Introduction, Planar Near Field Ranges, Errors, Cylindrical and Spherical Scanning.

### **Text Books:**

1. Antenna measurements techniques ,Evans, Gray E,Artech House,Inc  
ISBN: 9780890063750
2. Microwave Antenna Measurements ,J S Hollis, T J Lyon, L Clayton,Scientific Atlants,  
Inc. ISBN: B0017O8NDY

### **Reference Books:**

1. Antennas, J. D. Kraus, Mc Graw-Hill, ISE, 1988. ISBN-13, 978-0071004824
2. Antenna theory analysis and Design, Constantine A. Balanis, John Wiley. ISBN-13, 978-1118642061
3. Microwave Antenna –Theory and Design, Samuel Silver, IEE Press, London1984.ISBN-0863410170
4. Antenna Engineering Handbook ,John L. Volakis ,McGraw-Hill, ISBN-10, 0071475745

### **Weblinks:**

1. <http://nptel.ac.in/courses/117104127/2>
2. [https://en.wikipedia.org/wiki/Antenna\\_measurement](https://en.wikipedia.org/wiki/Antenna_measurement)

## Design Principles of Microwave Antennas

**Course Code: 2517EC04**

### UNIT-I:

**Antenna Parameters:** Antenna Definitions, Radiation Patterns, Radiation Power Density, Radiation Intensity, Gain, Antenna Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency, Antenna as an Aperture, Directivity and maximum Aperture, Friis Transmission Equation, Antenna Temperature.

### UNIT-II:

**Planar Antennas:** Microstrip rectangular and circular patch antennas- Analysis and design, feeding methods, Microstrip Feed, Coaxial Feed, Aperture-Coupled Feed, Proximity-Coupled (or Indirect) Feed, Characteristics of Microstrip Antennas, Return Loss, Radar Cross-section Impact of Different Parameters on Characteristics Methods of Analysis, Transmission-Line Model, Cavity Model, Full-wave Model.

### UNIT-III:

**Aperture Antennas:** Field Equivalence Principle, Huygens' Principle, Rectangular Apertures, Circular Apertures, Design Considerations.

**Reflector Antennas:** Plane Reflector, Corner Reflector, Parabolic Reflector, Spherical Reflector, Different feed types

### UNIT-IV:

**Frequency-Selective Surfaces and Periodic Structures:** Introduction basic Dipole and Slot FSS, Transmission and Reflection Properties of Simple Periodic Surfaces of Wires, Oblique Angle of Incidence, On the Shape and Development of Elements, Controlling Bandwidth with Angle of Incidence and Polarization

### UNIT-V:

**Smart Antennas for Mobile Communication:** Smart antenna, Smart-Antenna Analogy, Benefits of smart antenna, Smart-Antenna Systems, Types of smart antennas. Fixed Beam Smart antenna systems, Adaptive Antennas, Antenna Beam forming.

### Text Books:

1. Antennas and wave propagation ,J.D. Kraus, R J Marhefka, Ahmad S Khan 4<sup>th</sup> Edition Mc Graw-Hill ISBN: 9780070671553
2. Antenna theory analysis and Design, Constantine A. Balanis, 4<sup>th</sup> Edition, Wiley. ISBN-13, 978-1118642061

### Reference Books:

1. Microstrip Antenna Design Handbook ,Garg, R., Bhartia, P., Bahl, I. and Ittipiboon, A.ArtechHouse 2001. ISBN-10 0890065136-
2. Smart antennas for wireless Communication, T.S. Rappaport & J. C. Liberti Printice Hall,1999.ISBN: 9780137192878, 0137192878
3. Radio wave Propagation and Smart Antennas for Wireless Communications, Ramakrishna J, Kluwer Academic Publishers. ISBN-13 978-0792372417

### Weblinks:

1. [https://onlinecourses.nptel.ac.in/noc24\\_ee150/preview](https://onlinecourses.nptel.ac.in/noc24_ee150/preview)
2. <https://nptel.ac.in/courses/117107035>
3. <https://nptel.ac.in/courses/108101092>

## **Fundamentals of Semiconductor Fabrication Technology**

**Course Code: 2517EC05**

### **UNIT-I:**

#### **Clean Room Environment and Wafer Preparation:**

Crystal Structure of a solid, Defects in material. Types of clean room, Contamination in clean room, Electronic Grade Silicon Czochralski crystal growing, Silicon Shaping, Wafer cleaning processes and wet chemical etching techniques.

### **UNIT-II:**

#### **Oxidation, Diffusion, and Implantation:**

Kinetics of Silicon dioxide growth both for thick, thin, and ultrathin films; Oxidation Techniques and Systems Models of Diffusion in Solids, Defects due to oxidation, Solid State diffusion modeling and technology, Implantation Equipment, Principles, techniques and applications, removal of implant damage.

### **UNIT-III:**

#### **Epitaxial Growth:**

Metallization's and MBE, Defects in Epitaxial Layer Dielectric Deposition, PECVD and Rapid Thermal Annealing, E-beam evaporation, Sputtering, Thermal Evaporation, Dry Etching

### **UNIT-IV:**

#### **Lithography:**

Optical Lithography, E-beam lithography, X-ray, and Other Lithography techniques

### **UNIT-V:**

#### **Fabrication and Packaging:**

Fabrication of MOSFET, Process to Package a chip (Dicing, Attaching, wire bonding, Chip package header), Fabrications of other devices.

### **Text Books:**

1. VLSI Technology, S.M. Sze, McGraw Hill, 2nd Edition. 2008, ISBN-13 978-0070582910
2. Fundamentals of Semiconductor Fabrication, G. S. May, S. M. Sze, Wiley, 2003, ISBN-13 978-0471232797

### **Reference Books:**

1. Silicon VLSI Technology: fundamentals practice and Modeling, James D Plummer, Michael D. Deal, Peter Griffin, "", Prentice Hall India, 2009. ISBN-10-0130850373.
2. VLSI Technology, Wai Kai Chen, CRC press, 2003. ISBN-13- 978-0849317385.
3. VLSI Fabrication principles: Silicon and Gallium Arsenide S.K. Gandhi., 2ed, ISBN-13- 978-8126517909.

### **Weblinks:**

1. <https://nptel.ac.in/courses/117106093> - VLSI Technology, IIT Madras Dr. Nandita Dasgupta

## **Design and Analysis of VLSI subsystems**

**Course Code: 2517EC06**

### **UNIT – I:**

#### **CMOS Circuits:**

CMOS Transistors and Current model, CMOS Inverter and characteristics, Noise Margin.

### **UNIT – II:**

#### **Delay in CMOS Circuits:**

Delay of Inverter, RC Delay, Delay optimization Techniques

### **UNIT – III:**

#### **Combinatorial Circuit Family:**

Introduction to combinational circuits, Stick Diagram & Interconnects.

### **UNIT – IV:**

#### **Power in CMOS Circuits:**

Power, Dynamic Power, Static Power, and CMOS Latch and flip-flop design, Power optimization Techniques, Static Timing Analysis, importance of timing parameters in sequential circuits

### **UNIT – V:**

#### **Subsystem Design:**

Adder subsystem design, and Approximate Computing, Approximate computing data path subsystem designs

### **Text Books:**

1. CMOS VLSI Design A Circuits and Systems Perspective, N. Weste and D. Harris, 4th edition, Pearson.
2. Digital Integrated Circuits A Design Perspective, J M Rabaey, A. Chandrakasan, B. Nikolic, 2<sup>nd</sup> edition, Pearson.

### **Reference Books:**

1. Analog Integrated Circuit Design- David A. Johns, Ken Martin, Wiley Student Edn, 2013, ISBN-13- 978-8126543939
2. Analysis and Design of Analog Integrated Circuits, 5ed, ISV by Meyer Gray, Hurst, Lewis2009, ISBN-13- 978-8126521487

### **Weblinks:**

1. [https://onlinecourses.nptel.ac.in/noc25\\_ee18/preview](https://onlinecourses.nptel.ac.in/noc25_ee18/preview)

## Sensors and Actuators

**Course Code: 2517EC07**

### **UNIT – I:**

#### **Introduction:**

Basics of Energy Transformation: Transducers, Sensors and Actuators, Understanding of thin film physics: Application in MOSFET and its variants

### **UNIT – II:**

#### **Thin Film Deposition Techniques:**

Chemical Vapor Deposition (APCVD, LPCVD, UHVCVD, PECVD, ALCVD, HPCVD, MOCVD), Physical Vapor Deposition (Thermal Deposition, E-beam Evaporation, Sputtering, Pulsed Laser Deposition)

### **UNIT – III:**

#### **Photolithography:**

Basics understanding of Photolithography for patterning layer. Detailed overview of Etching methods.

### **UNIT – IV:**

#### **Sensors:**

Understanding various gas sensors: Optical gas sensor, Metal oxide semiconductor gas sensor, Field effect transistor gas sensor, Piezoelectric gas sensor, Polymer gas sensor, Nano-structured based gas sensors, Design and fabrication process of Microsensors: Force Sensors, Pressure Sensors, Strain gauges and practical applications

### **UNIT – V:**

#### **Actuators:**

Working principles of Actuators. Piezoelectric and Piezoresistive actuators, micropumps and micro actuators with practical applications, Understanding basics of microfluidics to assist Photomask design using Clewin Software, pattern transfer techniques, PDMS moulding and degassing, device bonding techniques, Simulation, Optimization and characterization of various sensors using COMSOL Multiphysics, Static and Dynamic Characteristic Parameters for Sensors and Actuators, Calibration of Sensor based electronics systems.

#### **Text Books:**

1. Sensors and Signal Conditioning Wiley-Blackwell, 2008 Jacob Fraden,
2. Handbook of modern sensors, Springer, Stefan Johann Rupitsch.
3. Piezoelectric Sensors and Actuators: Fundamentals and Applications, Springer, 2018 Senturia S. D.

#### **Reference Books:**

1. Silicon VLSI Technology, S.M. Sze Pearson Education, 2001
2. VLSI Technology, Madou ,2<sup>nd</sup> Edition, McGraw Hill, 1988

**Weblinks:**

1. [https://onlinecourses.nptel.ac.in/noc21\\_ee32/preview](https://onlinecourses.nptel.ac.in/noc21_ee32/preview)

# **Computer Vision and Image Processing Fundamentals and Applications**

**Course Code: 2517EC08**

## **UNIT-I:**

**Introduction to Computer Vision and Basic Concepts of Image Formation:** Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts, Radiometry, Geometric Transformations, Geometric Camera Models, Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections.

## **UNIT-II:**

### **Image Processing Concepts:**

Image Transforms, Image Transforms, Image Enhancement, Image Filtering, Colour Image Processing, Image Segmentation

## **UNIT-III:**

### **Image Descriptors and Features:**

Texture Descriptors, Colour Features, Edges/Boundaries, Object Boundary and Shape Representations, Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency

## **UNIT-IV:**

### **Fundamentals of Machine Learning:**

Linear Regression, Basic Concepts of Decision Functions, Elementary Statistical Decision Theory, Parameter Estimation, Clustering for Knowledge Representation, Dimension Reduction, Linear Discriminant Analysis.

## **UNIT-V:**

### **Applications of Computer Vision:**

Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoders, Gesture Recognition, Motion Estimation and Object Tracking, Programming Assignments.

## **Text Books:**

1. Computer Vision-A Modern Approach, Forsyth & Ponce, Pearson Education.
2. Computer Vision and Image Processing: Fundamentals and Applications”, CRC Press, M.K. Bhuyan, USA, ISBN 9780815370840 - CAT# K338147.
3. Computer Vision- Algorithms & Applications, Richard Szeliski Springer.

## **Reference Books:**

- 1 Digital Image Processing and Analysis-Human and Computer Vision Application with CVIP Tools – Scotte Umbaugh, 2<sup>nd</sup> Ed, CRC Press, 2011. ISBN-10-9781439802052.
- 2 Digital Image Processing, Jayaraman, S. Esakkirajan, and T. Veerakumar, Tata McGraw-Hill Education, 1<sup>st</sup> edition, 2011, ISBN-13-978-0070144798.

## **Weblinks:**

- 1 [https://onlinecourses.nptel.ac.in/noc24\\_ee38/preview](https://onlinecourses.nptel.ac.in/noc24_ee38/preview) - Computer Vision and Image Processing - Fundamentals and Applications, by Prof. M. K. Bhuyan, IIT Guwahati.

## Multimedia and Signal Coding

**Course Code: 2517EC09**

### **UNIT-I:**

#### **Introduction to Multimedia:**

Multimedia, World Wide Web, Overview of Multimedia Tools, Multimedia Authoring, Graphics/ Image Data Types, and File Formats.

#### **Color in Image and Video:**

Color Science – Image Formation, Camera Systems, Gamma Correction, Color Matching Functions, CIE Chromaticity Diagram, Color Monitor Specifications, Out of- Gamut Colors, White Point Correction, XYZ to RGB Transform, Transform with Gamma Correction, L\*A\*B\* Color Model. Color Models in Images – RGB Color Model for CRT Displays, Subtractive Color: CMY Color Model, Transformation from RGB to CMY, Under Color Removal: CMYK System, Printer Gamuts, Color Models in Video – Video Color Transforms, YUV Color Model, YIQ Color Model, Ycber Color Model.

### **UNIT-II:**

#### **Video Concepts:**

Types of Video Signals, Analog Video, Digital Video.

#### **Audio Concepts:**

Digitization of Sound, Quantization and Transmission of Audio.

### **UNIT-III:**

#### **Compression Algorithms:**

##### **Lossless Compression Algorithms:**

Run Length Coding, Variable Length Coding, Arithmetic Coding, Lossless JPEG, Image Compression.

##### **Lossy Image Compression Algorithms:**

Transform Coding: KLT And DCT Coding, Wavelet Based Coding.

**Image Compression Standards:** JPEG and JPEG2000.

### **UNIT-IV:**

#### **Video Compression Techniques:**

Introduction to Video Compression, Video Compression Based on Motion Compensation, Search for Motion Vectors, H.261- Intra-Frame and Inter-Frame Coding, Quantization, Encoder and Decoder, Overview of MPEG1 and MPEG2.

### **UNIT-V:**

#### **Audio Compression Techniques:**

ADPCM in Speech Coding, G.726 ADPCM, Vocoders – Phase Insensitivity, Channel Vocoder, Formant Vocoder, Linear Predictive Coding, CELP, Hybrid Excitation, Vocoders, MPEG Audio – MPEG Layers, MPEG Audio Strategy, MPEG Audio Compression Algorithms, MPEG-2 AAC, MPEG-4 Audio.

#### **Text Books:**

1. Fundamentals of Multimedia – Ze- Nian Li, Mark S. Drew, PHI, 2010. ISBN-13978-8177588231.
2. Multimedia Signals & Systems – Mrinal Kr. Mandal Springer International Edition 1st Edition, 2009. ISBN-13 : 978-1461349945

**Reference Books:**

1. Multimedia Communication Systems – Techniques, Stds & Netwroks K.R. Rao, Zorans. Bojkoric, Dragorad A. Milovanovic, 1st Edition, 2002. ISBN-13-978-0130313980
2. Digital Video Processing – A.M. Tekalp, Prentice Hall International, SBN-13-978-0133991000
3. Video Processing and Communication – Yao Wang, Joem Ostermann and Ya–quin Zhang. 1<sup>st</sup> Ed., PH Int. ISBN-13-978-0130175472.

**Weblinks:**

1. <https://nptel.ac.in/courses/117105083> (Prof. Somnath Sengupta, IIT Kharagpur)
2. <http://nptel.ac.in/courses/117105079/>( Prof. P.K. Biswas, IIT Kharagpur)
3. <https://nptel.ac.in/courses/117105081>(Prof. Somnath Sengupta, IIT Kharagpur)

## **Applied Linear Algebra for Machine Learning based WC**

**Course Code: 2517EC10**

### **UNIT – I:**

Vectors and Matrices: Vectors: Addition, linear combination, inner product, orthogonality, norm, unit norm vector, Cauchy- Schwarz inequality, Gram-Schmidt orthogonalization.

Matrices: Addition and multiplication of matrices, column space, linear independence, rank of matrix, Gaussian elimination, determinant and inverse computation, inverse computation for under and over determined system, adjoint and cofactor concepts, Null space, rank-nullity theorem, Eigen Value Decomposition, special matrices-rotation and unitary matrices, Positive Semi-Definite (PSD) matrices, Singular Value Decomposition (SVD), Woodbury matrix identity-matrix inversion lemma.

### **UNIT – II:**

Convex Optimization: Introduction to Convex sets and properties, Introduction to Polyhedral sets, Separation theorems for convex sets, Introduction to Convex function, examples, Continuity and differentiability properties of convex functions, Non-differentiable convex functions, Test for convexity: positive semi-definite Hessian matrix Hyperplanes/Half-spaces, Convex Optimization problems, Linear Program, Application: Power allocation in Multi-cell Multiuser OFDM based wireless scenario.

### **UNIT – III:**

Machine Learning Application: Gaussian random variable-mean, variance, multivariate Gaussian, covariance matrix, linear transformation of Gaussian random vectors, Gaussian classification, Eigen value decomposition for principal component analysis (PCA) and face recognition, SVD for PCA Analysis, linear regression, support vector machines (SVM), Introduction to Convex optimization problem in SVM, Compressive sensing-sparse regression, orthogonal matching pursuit (OMP) algorithm, Clustering in ML.

### **UNIT – IV:**

Application in Signal Processing for Wireless Communication: Structure of FFT/ IFFT matrices, properties, IFFT / FFT application in Orthogonal Frequency Division Multiplexing (OFDM) wireless technology, System model for OFDM/SC-FDMA, Circulant matrices and properties, OFDM system model: Transmitter and Receiver signal processing aspects, Inner product in MIMO beamforming application, system of linear equations in MIMO wireless technology, Rotation and unitary matrices in Alamouti codes, Linear Minimum Mean Square Estimate (LMMSE) for wireless channel estimation, multi-antenna channel estimation.

### **UNIT – V:**

Data Analytics and Miscellaneous Applications: Time-series prediction via autoregressive (AR) model, recommender system-design and rating prediction, data prediction models. Application of matrices in Graph Theory, Electrical circuits, social networks and traffic flow management, Application of Null space in Electric circuits, Introduction to Stochastic processes Markov chains, Discrete time Markov chain and its limiting behavior, inventory management, supply chain management.

**Text Books:**

1. Introduction to applied linear algebra: vectors, matrices, and least squares, Boyd, Stephen, and Lieven Vandenberghe, Cambridge university press, 2018. ISBN-101316518965
2. Introduction to linear algebra, Strang, Gilbert, Gilbert Strang, Gilbert Strang, and Gilbert Strang, Wellesley-Cambridge Press, 2016. ISBN-13-978-0980232776

**Reference Books:**

1. Applied Linear Algebra, Peter J. Olver and Chehrzad Shakiban, Prentice Hall, 2006, ISBN 0131473824, 9780131473829.
2. Signal design for good correlation: for wireless communication, cryptography, and radar, Golomb, Solomon W., and Guang Gong, Cambridge University Press, 2005, ISBN-13-978-0521821049.

**Weblinks:**

1. [https://onlinecourses.nptel.ac.in/noc20\\_ee59/preview](https://onlinecourses.nptel.ac.in/noc20_ee59/preview)
2. [https://onlinecourses.nptel.ac.in/noc21\\_ee33/preview](https://onlinecourses.nptel.ac.in/noc21_ee33/preview)
3. [https://onlinecourses.nptel.ac.in/noc21\\_cs85/preview](https://onlinecourses.nptel.ac.in/noc21_cs85/preview)
4. [https://onlinecourses.nptel.ac.in/noc24\\_ee146/course](https://onlinecourses.nptel.ac.in/noc24_ee146/course)

## Deep Learning

**Course Code: 2517EC11**

### **UNIT – I:**

#### **Introduction:**

History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks, Feed Forward Neural Networks, Backpropagation

### **UNIT – II:**

#### **Gradient Descent and Principal Component Analysis:**

Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition, Principal Component Analysis and its interpretations, Singular Value Decomposition, Autoencoders and relation to PCA

### **UNIT – III:**

#### **Regularization and Normalization:**

Bias Variance Trade-off, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layer wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization.

### **UNIT – IV:**

#### **Convolutional Neural Networks:**

LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks

### **UNIT – V:**

#### **Recurrent Neural Networks:**

Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs, Encoder Decoder Models, Autoencoders, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders, Attention Mechanism, Attention over images.

### **Text Books:**

- 1 Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville  
MIT Press.
- 2 Deep Learning, John D. Kelleher, MIT Press
- 3 Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence,  
Jon Krohn , Grant Beyleveld , Aglae Bassens , 1st edition, Pearson Education.

**Reference Books:**

1. Machine Learning, Tom M. Mitchell, First edition, McGraw Hill Education, 2017. ISBN-10-1259096955
2. Deep Learning for Computer Vision with Python, Adrian Rosebrock Packt Publisher, 2018.

**Weblinks:**

1. [https://onlinecourses.nptel.ac.in/noc20\\_cs62/preview](https://onlinecourses.nptel.ac.in/noc20_cs62/preview)
2. [https://onlinecourses.nptel.ac.in/noc24\\_cs101/preview](https://onlinecourses.nptel.ac.in/noc24_cs101/preview)
3. [https://onlinecourses.nptel.ac.in/noc24\\_ee146/course](https://onlinecourses.nptel.ac.in/noc24_ee146/course)
4. <http://www.deeplearningbook.org>

## Signal Transform Techniques

**Course Code: 2517EC12**

### **UNIT-I:**

#### **Fourier Analysis:**

Fourier series, Examples, Fourier Transform, Properties of Fourier Transform, Examples of Fourier transform, sampling theorem, Partial sum and Gibbs phenomenon, Fourier analysis of Discrete time Signals, Discrete Fourier Transform.

Time – Frequency Analysis: Window function, Short Time Fourier Transform, Discrete Short Time Fourier Transform, Continuous wavelet transform, discrete wavelet transform, wavelet series, Interpretations of the Time-Frequency plot.

### **UNIT-II:**

#### **Transforms:**

Walsh, Hadamard, Haar and Slant Transforms, DCT, DST, KLT, Singular value Decomposition– definition, properties and applications.

### **UNIT-III**

#### **Continuous Wavelet Transform (CWT):**

Shortcomings of STFT, Need for wavelets, Wavelet Basis- Concept of Scale and its relation with frequency, Continuous time wavelet Transform Equation-Series Expansion using Wavelets- CWT- Tiling of time scale plane for CWT. Important Wavelets: Haar, Mexican Hat, Meyer, Shannon, Daubechies.

### **UNIT-IV:**

#### **Multi Rate Analysis and DWT:**

Need for Scaling function – Multi Resolution Analysis, Two- Channel Filter Banks, Perfect Reconstruction Condition, Relationship between Filter Banks and Wavelet Basis, DWT, Structure of DWT Filter Banks, Daubechies Wavelet Function, Applications of DWT.

### **UNIT-V:**

#### **Wavelet Packets and Lifting:**

Wavelet Packet Transform, Wavelet packet algorithms, Thresholding-Hard thresholding, Soft thresholding, Multidimensional Wavelets, Bi orthogonal basis-B-Splines, Lifting Scheme of Wavelet Generation, Multi Wavelets.

#### **Text Books:**

1. A Wavelet Tour of Signal Processing theory and applications-Raghuveer M.Rao and Ajit's. Bopardikar, Pearson Edu, Asia, New Delhi,2003.
2. Insight into Wavelets—from theory to practice K. P. Soman and K.I Rama Chandran, PHI, Second edition,2008 ISBN-13-978-8120340534.

#### **Reference Books:**

1. Fundamentals of Wavelets-Theory, Algorithms and Applications- Jaideva C Goswami, Andrew K Chan, John Wiley& Sons, Inc, Singapore, 1999. ISBN-13-978-0470484135
2. A Wavelet Tour of Signal Processing- Stephen G. Mallat, AcademicPress,2Ed, ISBN: 9780080520834
3. Digital Image Processing, Jayaraman, S. Esakkirajan, and T. Veerakumar,Tata McGraw-Hill Education,1st edition, 2011,I SBN-13-978-0070144798.

**Weblinks:**

1. <https://archive.nptel.ac.in/courses/111/106/111106111/> - Transform Techniques for Engineers, by S.R. Manam, IIT Madras.

## Speech Signal Processing

**Course Code: 2517EC13**

### **UNIT-I:**

#### **Digital Speech Processing:**

Anatomy & Physiology of Speech Organs, The process of Speech Production, Acoustic Phonetics, Articulatory Phonetics, The Acoustic Theory of Speech Production- Uniform lossless tube model, effect of losses in vocal tract, effect of radiation at lips, Digital models for speech signals.

### **UNIT-II:**

#### **Time Domain Models for Speech Processing: Introduction:**

Window considerations, Short time energy and average magnitude Short time average zero crossing rate, Speech Vs Silence discrimination using energy and zero crossing, Pitch period estimation using a parallel processing approach, The short time autocorrelation N function, The short time average magnitude difference function, Pitch period estimation using the autocorrelation function.

### **UNIT-III:**

Linear Predictive Coding (LPC) Analysis: Basic principles of Linear Predictive Analysis: The Autocorrelation Method, The Covariance Method, Solution of LPC Equations: Cholesky Decomposition Solution for Covariance Method, Durbin's Recursive Solution for the Autocorrelation Equations, Comparison between the Methods of Solution of the LPC Analysis Equations, Applications of LPC Parameters: Pitch Detection using LPC Parameters, Formant Analysis using LPC Parameters.

### **UNIT-IV:**

#### **Homomorphic Speech Processing:**

Introduction, Homomorphism Systems for Convolution: Properties of the Complex Cepstrum, Computational Considerations, The Complex Cepstrum of Speech, Pitch Detection, Formant Estimation, The Homomorphism Vocoder.

#### **Speech Enhancement:**

Nature of interfering sounds, Speech enhancement techniques: Single Microphone Approach: spectral subtraction, Enhancement by re-synthesis, Comb filter, Wiener filter, Multimicrophone Approach.

### **UNIT-V:**

#### **Automatic Speech & Speaker Recognition:**

Basic pattern recognition approaches, parametric representation of speech, evaluating the similarity of speech patterns, isolated digit Recognition System, Continuous digit Recognition System

#### **Hidden Markov Model (HMM) for Speech:**

Hidden Markov Model (HMM) for speech recognition, Viterbi algorithm, Training and testing using HMMS.

**Speaker Recognition:** Recognition techniques, Features that distinguish speakers, Speaker Recognition Systems: Speaker Verification System, Speaker Identification System.

**Text Books:**

1. Digital Processing of Speech Signals, L.R. Rabiner and R.W. Schafer, Pearson Education, Delhi, India, 2004, ISBN-13-978-8131705131.
2. Fundamentals of speech recognition, L. R. Rabiner, B. H. Jhuang and B. Yegnanarayana, Pearson Education, 2009. ISBN-10-8177585606, ISBN-13-978-8177585605

**Reference Books:**

1. Speech & Audio Signal Processing- Ben Gold & Nelson Morgan, 1st Ed., Wiley. Print ISBN:9780470195369 |Online ISBN:9781118142882.
2. Discrete Time Speech Signal Processing: Principles and Practice - Thomas F. Quateri, 1st Ed., PE. ISBN-10-013242942X, ISBN-13978-0132429429.
3. Statistical Methods of Speech Recognition, Frederick Jelinek, MIT Press, 2022, ISBN-10: 0262546604, ISBN-13: 978-0262546607.

**Weblinks:**

1. <https://www.youtube.com/watch?v=TQ7Y7ZgDOa8> (Daniel kang, Full stack Academy)
2. <https://nptel.ac.in/courses/117105145/> (Prof. Shyamal Kumar Das Mandal, IIT Kharagpur)

## **Bio-Medical Signal Processing**

**Course Code: 2517EC14**

### **UNIT-I:**

#### **Random Processes:**

Stationary random process, Ergodicity, Power spectral density and autocorrelation function of random processes. Noise power spectral density analysis, Noise bandwidth and noise figure of systems.

### **UNIT-II:**

#### **Data Compression Techniques:**

Lossy and Lossless data reduction Algorithms, ECG data compression using Turning point, AZTEC, CORTES, Huffman coding, vector quantization, DICOM Standards

### **UNIT-III:**

#### **Cardiological Signal Processing:**

Pre-processing, QRS Detection Methods, Rhythm analysis, Arrhythmia Detection Algorithms, Automated ECG Analysis, ECG Pattern Recognition.

#### **Adaptive Noise Cancelling:**

Principles of Adaptive Noise Cancelling, Adaptive Noise Cancelling with the LMS Adaptation Algorithm, Noise Cancelling Method to Enhance ECG Monitoring, Fetal ECG Monitoring.

### **UNIT-IV:**

#### **Signal Averaging, Polishing:**

Mean and trend removal, Prony's method, Prony's Method based on the Least Squares Estimate, Linear prediction, Yule – Walker (Y –W) equations, Analysis of Evoked Potentials.

### **UNIT-V:**

#### **Neurological Signal Processing:**

Modelling of EEG Signals, Detection of spikes and spindles Detection of Alpha, Beta and Gamma Waves, Auto Regressive (A.R.) modelling of seizure EEG, Sleep Stage analysis, Inverse Filtering, Least squares and polynomial modelling.

### **Text Books:**

1. Probability, Random Variables & Random Signal Principles – Peyton Z. Peebles, 4th Ed., 2009, TMH, ISBN-13-978-0070474284
2. Biomedical Signal Processing- Principles and Techniques - D. C. Reddy, 2005, TMH, ISBN-13-978-0070583887

### **Reference Books:**

1. Digital Bio signal Processing - Weitkunar R, 1991, Elsevier.
2. Biomedical Signal Processing -Vol. I Time & Frequency Analysis - Cohen. A, 1986, CRC Press.
3. Biomedical Digital Signal Processing: C-Language Experiments and Laboratory Experiments, Willis J. Tompkins, PHI. ISBN-13-978-8120314788

**Weblinks:**

1. <https://www.bhf.org.uk/heart-health/treatments/pacemakers>
2. [https://nptel.ac.in/courses/108105063/pdf/L-07\(SS\)\(IA&C\)%20\(\(EE\)NPTEL\).pdf](https://nptel.ac.in/courses/108105063/pdf/L-07(SS)(IA&C)%20((EE)NPTEL).pdf)
3. <https://www.egr.msu.edu/classes/ece445/mason/Files/7-BioAmps.pdf>
4. <https://www.healthline.com/health/ct-scan>

## Modern Mobile Communication Systems

**Course Code: 2517EC15**

### **UNIT-I:**

#### **Large-Scale Path Loss:**

Propagation of EM signals in wireless channel, Reflection, Diffraction and scattering, Free space propagation model, Two ray ground reflection model, Log-distance path loss model, Small-Scale Fading and Multipath: Parameters of mobile multipath channels, Types of small-scale fading, Rayleigh and Rician distributions, Jakes Doppler spectrum.

### **UNIT-II:**

#### **Diversity Techniques:**

Condition for deep fading, Probability of error analysis under fading channel, Time diversity, Repetition codes, Frequency diversity, Spatial diversity techniques, Analysis of BER of multi antenna system, Diversity order.

### **UNIT-III:**

#### **Physical Layer Aspects of LTE and LTE-A:**

Requirements and targets of LTE, Introduction to downlink physical layer design, Transmission resource structure, Synchronization and cell search, Reference signals and channel estimation, Cell specific reference signal generation, UE specific reference signal generation, Downlink physical data and control channels, Link adaptation, Introduction to uplink physical layer design, Carrier aggregation, HARQ, Relaying strategies and benefits.

### **UNIT-IV:**

#### **OFDM:**

Introduction to multicarrier modulation, Importance of cyclic prefix, Adaptive modulation and coding techniques. OFDM issues, PAPR, Frequency and timing offset, ICI mitigation techniques, Introduction to SC-FDMA-PAPR analysis with localized and interleaved schemes.

### **UNIT-V:**

#### **MIMO and Recent Trends:**

Spatial multiplexing, Decomposition of MIMO channel, Pre-coding, Optimal MIMO power allocation, MIMO beamforming, Nonlinear MIMO receivers-V-BLAST, D-BLAST, Requirements of 5G, Drawbacks of OFDM, Introduction to Filter Bank Multicarrier System (FBMC), Massive MIMO, Millimeter wave technology, Dense network, Cognitive radio technology, Smart antennas, Multi-hop relay networks.

### **Text Books:**

1. Principles of Modern Wireless Communications Systems, Aditya K. Jagannatham, 2015, 1st Edition, McGraw-Hill Education, India, ISBN-13-978-1259029578.
2. Millimeter wave wireless communications ,Theodore S. Rappoport, Robert C. Danials, James N. Murdoc, Prentice Hall Communications,2015,1<sup>st</sup> Edition, ISBN-13-978-0132172288.

**Reference Books:**

1. Modern Wireless Communications, Simon Haykin, Michael Moher, 2011, 1st Edition, Pearson Education, India, ISBN-13-978-8131704431
2. 5G mobile communications, Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, Springer, 2017, 1<sup>st</sup> Edition. ISBN-13-978-3319342061
3. Wireless Communication and Networking -William stallings, 2003, PHI.

**Weblinks:**

1. <http://nptel.ac.in/courses/117104099/>-Modern Wireless Mobile Communication Systems

## Mobile Computing Technologies

**Course Code: 2517EC16**

### **UNIT I:**

#### **Introduction to Mobile Computing Architecture:**

Mobile Computing – Dialog Control – Networks – Middleware and Gateways – Application and Services – Developing Mobile Computing Applications – Security in Mobile Computing – Architecture for Mobile Computing – Three Tier Architecture – Design considerations for Mobile Computing – Mobile Computing through Internet – Making existing Applications Mobile Enabled.

### **UNIT II:**

#### **Cellular Technologies:**

GSM, GPS, GPRS, CDMA and 3G: Bluetooth – Radio Frequency Identification – Wireless Broadband – Mobile IP – Internet Protocol Version 6 (IPv6) – Java Card – GSM Architecture – GSM Entities – Call Routing in GSM – PLMN Interfaces – GSM addresses and Identifiers – Network aspects in GSM – Authentication and Security – Mobile computing over SMS – GPRS and Packet Data Network – GPRS Network Architecture – GPRS Network Operations – Data Services in GPRS – Applications for GPRS – Limitations of GPRS – Spread Spectrum technology – Is95 – CDMA Versus GSM – Wireless Data – Third Generation Networks – Applications on 3G

### **UNIT III:**

#### **Wireless Application Protocol (WAP) and Wireless LAN:**

WAP – MMS – Wireless LAN Advantages – IEEE 802.11 Standards – Wireless LAN Architecture – Mobility in wireless LAN Intelligent Networks and Interworking: Introduction – Fundamentals of Call processing – Intelligence in the Networks – SS#7 Signaling – IN Conceptual Model (INCM) – soft switch – Programmable Networks – Technologies and Interfaces for IN

### **UNIT IV:**

#### **Client Programming, Palm OS, Symbian OS, Win CE Architecture:**

Introduction – Moving beyond the Desktop – A Peek under the Hood: Hardware Overview – Mobile phones – PDA – Design Constraints in Applications for Handheld Devices – Palm OS architecture – Application Development – Multimedia – Symbian OS Architecture – Applications for Symbian, Different flavors of Windows CE -Windows CE Architecture J2ME: JAVA in the Handset – The Three-prong approach to JAVA Everywhere – JAVA 2 Micro Edition (J2ME) technology – Programming for CLDC – GUI in MIDP – UI Design Issues – Multimedia – Record Management System – Communication in MIDP – Security considerations in MIDP – Optional Packages

### **UNIT V:**

#### **Voice Over Internet Protocol and Convergence:**

Voice over IP- H.323 Framework for Voice over IP – Session Initiation Protocol – Comparison between H.323 and SIP – Real Time protocols – Convergence Technologies – Call Routing – Voice over IP Applications – IP multimedia subsystem (IMS) – Mobile VoIP Security Issues in Mobile Computing: Introduction – Information Security – Security Techniques and Algorithms – Security Protocols – Public Key Infrastructure – Trust – Security Models – Security frameworks for Mobile Environment.

**Text Books:**

- 1 Mobile Computing – Technology, Applications and Service Creation – Asoke K Talukder, Roopa R Yavagal, 2009, TATA McGraw Hill, ISBN-13-978-0070144576
- 2 Mobile Communications – Jochen Schiller – 2 nd Edition – Pearson Education, ISBN-13-978-8131724262

**Reference Books:**

- 1 The CDMA 2000 System for Mobile Communications – Vieri Vaughi, Alexander Damn Jonvic – Pearson, ISBN-10-8131707776
- 2 Fundamentals of Mobile & Parvasive Computing, Adalestein -2008, TMH, ISBN-13 978-0070603646

**Weblinks:**

1. <https://nptel.ac.in/courses/117102062/4>
2. [https://onlinecourses.nptel.ac.in/noc21\\_ee66/preview](https://onlinecourses.nptel.ac.in/noc21_ee66/preview)

## Advanced Wireless Networks

Course Code: 2517EC17

### UNIT-I:

#### Fundamentals of Cellular systems and Geo location systems:

Cellular concept, Frequency reuse, Channel assignment strategies, Handoff strategies, Interference & system capacity, Trunking & grade of service, Improving coverage and capacity in cellular system, Wireless Geo Location Systems-Architecture, Technologies, Geo location standards for E-911 Services and Performance measures.

### UNIT-II:

#### Diversity Techniques:

Derivation of selection Diversity improvement, Derivation of Maximal Ratio Combining improvement, Practical Space Diversity Consideration-Selection Diversity, Feedback or Scanning Diversity, Maximal Ratio Combining, Equal Gain Combining, Polarization Diversity, Frequency Diversity, Time Diversity, RAKE Receiver.

### UNIT –III:

#### Wireless Networks:

Introduction to wireless Networks, Advantages and disadvantages of Wireless Local Area Networks, WLAN Topologies, WLAN Standard IEEE 802.11, IEEE 802.11 Medium Access Control, Comparison of IEEE 802.11 a, b, g and n standards, IEEE 802.16 and its enhancements, Wireless PANs, Hiper Lan, WLL.

### UNIT-IV:

#### Equalization Techniques:

Introduction, Fundamentals of Equalization, Training A Generic Adaptive Equalizer, Equalizers in a communication Receiver, Linear Equalizers, Nonlinear Equalization-Decision Feedback Equalization (DFE), Maximum Likelihood Sequence Estimation (MLSE) Equalizer, Algorithms for adaptive equalization-Zero Forcing Algorithm, Least Mean Square Algorithm, Recursive least squares algorithm.

### UNIT-V:

#### Ad Hoc Networks:

Introduction and Historical View of LAN, WAN, MAN, Evolution of WLAN, New interests from Military and Service Providers, IEEE 802.11 WLANS, Wireless ATM and HYPERLAN Wireless Home Networking.

#### Text Books:

1. Principles of Wireless Networks – Kaveh Pah Laven and P. Krishna Murthy, 2002, PE, ISBN-13-978-0130930033
2. Wireless communications, Rappaport, T.S.,2012 (Reprint), 2nd edition, Pearson Education, Noida, India, ISBN-13-978-8131731864

#### Reference Books:

1. Wireless Communications, T L Singal, 2014 (Reprint), Tata McGraw Hill Education, 1st edition, New Delhi, India, ISBN-13-978-0070681781.
2. Wireless Digital Communications – Kamilo Feher, 1999, PHI, ISBN-10-9789332549401, ISBN-13-978-9332549401.

3. Wireless Communication and Networking – William Stallings, 2003, PHI.
4. Wireless Communication – Upen Dalal, Oxford Univ. Press

**Weblinks:**

1. <https://archive.nptel.ac.in/courses/117/102/117102062/>
2. <https://nptel.ac.in/courses/108106370>

## Advanced 5G Wireless Communications

**Course Code: 2517EC18**

### **UNIT-I:**

#### **Overview of 5G Broadband Wireless Communications:**

Evaluation of mobile technologies 1G to 4G (LTE, LTEA, LTEA Pro), An Overview of 5G requirements, Regulations for 5G, Spectrum Analysis and Sharing for 5G.

### **UNIT-II:**

#### **RF FRONT END FOR 5G:**

Millimeter Wave Communications: Hardware technologies for mmW systems – Architecture and Mobility – Massive MIMO: Resource allocation and transceiver algorithms for massive MIMO - Fundamentals of baseband and RF implementations in massive MIMO - Beamforming.

### **UNIT-III:**

#### **Transmission and Design Techniques for 5G:**

Basic requirements of transmission over 5G, Modulation Techniques – Orthogonal frequency division multiplexing (OFDM), generalized frequency division multiplexing (GFDM), filter bank multi-carriers (FBMC) and universal filtered multi-carrier (UFMC), Multiple Accesses Techniques – orthogonal frequency division multiple accesses (OFDMA), generalized frequency division multiple accesses (GFDMA), non-orthogonal multiple accesses (NOMA).

### **UNIT-IV:**

#### **Interference management, mobility management, and security for 5G:**

Network deployment types, Ultra-dense network or densification, Moving networks, Heterogeneous networks, Interference management in 5G, Interference management in UDN, Interference management for moving relay nodes, Interference cancellation, Mobility management in 5G, User equipment controlled versus network-controlled handover, Mobility management in heterogeneous 5G networks.

#### **Device-to-device (D2D) and machine-to-machine (M2M) type communications:**

Extension of 4G D2D standardization to 5G, radio resource management for mobile broadband D2D, multi-hop and multi-operator D2D communications.

### **UNIT-V:**

#### **Millimeter-wave Communications:**

spectrum regulations, deployment scenarios, physical layer techniques, interference and mobility management, Massive MIMO propagation channel models, Channel Estimation in Massive MIMO, Massive MIMO with Imperfect CSI, Multi-Cell Massive MIMO, Pilot Contamination, Spatial Modulation (SM)

### **Text Books:**

1. From GSM to LTE–Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband, Martin Sauter, Wiley-Blackwell, 2017, 2<sup>nd</sup>Edition, ISBN-10-1119714672.
2. New Directions in Wireless Communication Systems from Mobile to 5G, Athanasios G. Kanatos, Konstantina S. Nikita, Panagiotis Mathiopoulos, CRC Press, 2018, 1<sup>st</sup>Edition, ISBN-13-978-0367572877.

**Reference Books:**

1. Fundamentals of 5G Mobile Networks, Jonathan Rodriguez, John Wiley & Sons, 2015,1<sup>st</sup> Edition, ISBN-13-978-1118867525
2. Essentials of LTE and LTE-A, Amitabha Ghosh and Rapeepat Ratasuk ,Cambridge University Press, 2011 1<sup>st</sup>Edition,ISBN-1138500538,9781139500531.
3. 5G Mobile Communications ,Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, Springer, 2017, 1<sup>st</sup> Edition, ISBN-13-978-3319342061

**Weblinks:**

1. <https://nptel.ac.in/courses/108105134>
2. [https://onlinecourses.nptel.ac.in/noc24\\_ee152](https://onlinecourses.nptel.ac.in/noc24_ee152)

## **Embedded System Design with ARM**

**Course Code: 2517EC19**

### **UNIT-I:**

#### **ARM Architecture and Instruction Sets:**

ARM Processor Modes-ARM CPU Registers: General Registers, Status Registers- Change ARM Processor Mode- Instruction Pipeline- the ARM Architecture: The Acorn RISC Machine, Architectural inheritance, ARM development tools - ARM Instructions set Software Interrupt.

### **UNIT-II:**

#### **Architectural Support for System Development:**

The ARM memory interface: ARM bus signals, Simple memory interface, Control logic, Wait states, DRAM, Peripheral access- The Advanced Microcontroller Bus Architecture, Base components, Memory map, Interrupt controller, Counter timers, Reset and pause controller.

### **UNIT-III:**

#### **Memory Hierarchy and Cache:**

Memory size and speed, On chip memory, Unified and Harvard caches, Cache organization techniques - Memory Hierarchy and Cache memory, Memory management units, Cache Architecture, Write buffers, Measuring cache efficiency - Cache policy, write policy thorough - coprocessor and caches, Cleaning cache memory.

### **UNIT-IV:**

#### **ARM Interrupts and Exceptions Processing:**

ARM Exceptions: Exception handling, Arm Processor exceptions and modes, Exceptions Vector Table - Interrupts and Interrupts Processing: Interrupt Types, Interrupt Controllers, Primary and Secondary Interrupt Controllers- Interrupt Processing: Vector Table Contents, Hardware Interrupt Sequence, Interrupts Control in Software, Interrupt Handlers, Non-nested Interrupt Handler.

### **UNIT-V:**

#### **Embedded ARM Applications:**

ARM710T, The ARM710T cache organization, Cache power, Sequential accesses, Power optimization, ARM710TMMU, ARM710T write buffer- The ARMSIO, ARMS 10 characteristics, Double bandwidth cache- The VLSI Ruby II Advanced Communication Processor, Ruby II organization, Packaging - The VLSI ISDN Subscriber Processor, VIP organization, Memory interface.

**Text Books:**

1. Embedded and Real-Time Operating Systems, Wang, Springer, 2<sup>nd</sup> Edition, ISBN-13978-3319515168
2. ARM System-on-Chip Architecture, Steve Furber, Pearson Education, 2<sup>nd</sup> Edition, ISBN-100201675196, ISBN-13978-0201675191

**Reference Books:**

1. Embedded system design: a unified hardware/software introduction, Vahid, Frank and Givargis, Tony, Vol. 52, Wiley New York, ISBN-10-812650837X, ISBN-13-978-8126508372.
2. Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed, Xiao, Perry, Wiley Online Library, 2018, ISBN-10-1119363993, ISBN-13-978-1119363996
3. ARM system developers guide Andrew Sloss ET al, Designing and optimizing system, Elsevier, ISBN-10-8181476468, ISBN-13-978-8181476463

**Weblinks:**

1. <https://archive.nptel.ac.in/courses/106/105/106105193>
2. <https://archive.nptel.ac.in/courses/108/102/108102045/>

## **Embedded Networking**

**Course Code: 2517EC20**

### **UNIT-I:**

#### **Embedded Communication Protocols:**

Embedded Networking: Introduction, Serial/Parallel Communication, Serial communication protocols-RS232 standard, RS485 – Synchronous Serial Protocols, Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C), PC Parallel port programming - ISA/PCI Bus protocols – Firewire.

### **UNIT-II:**

#### **USB and CAN Bus:**

USB bus – Introduction – Speed Identification on the bus – USB States – USB bus communication: Packets –Data flow types –Enumeration –Descriptors –PIC 18 Microcontroller USB Interface – C Programs –CAN Bus – Introduction - Frames –Bit stuffing –Types of errors –Nominal Bit Timing – PIC microcontroller CAN Interface –A simple application with CAN.

### **UNIT-III:**

#### **Ethernet Basics:**

Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed – Design choices: Selecting components – Ethernet Controllers – Using the internet in local and internet communications – Inside the Internet protocol.

### **UNIT-IV:**

#### **Embedded Ethernet:**

Exchanging messages using UDP and TCP – Serving web pages with Dynamic Data – Serving web pages that respond to user Input – Email for Embedded Systems – Using FTP – Keeping Devices and Network secure.

### **UNIT-V:**

#### **Wireless Embedded Networking:**

Wireless sensor networks – Introduction, Applications, Network Topology, Localization, Time Synchronization, Energy efficient MAC protocols –SMAC – Energy efficient and robust routing – Data Centric routing.

### **Text Books:**

1. Embedded system design: a unified hardware/software introduction, Vahid, Frank and Givargis, Tony, Vol. 52, Wiley New York, ISBN-10-812650837X,ISBN-13-978-8126508372.
2. Parallel Port Complete: Programming, interfacing and using the PCs parallel printer port - Jan Axelson, Penram Publications, 1996, ISBN-10-0965081915,ISBN-13-978-0965081917

**Reference books:**

1. Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F series - Dogan Ibrahim, Elsevier 2008, ISBN-13-978-0750686112
2. Embedded Ethernet and Internet Complete - Jan Axelson, Penram publications, 2003, ISBN- 1931448000, 9781931448000.
3. Networking Wireless Sensors - Bhaskar Krishnamachari, Cambridge press 2005, ISBN-10-0521838479, ISBN-13-978-0521838474.

**Weblinks:**

1. <http://nptel.iitm.ac.in>

## Computer Vision

**Course Code: 2517EC21**

### **UNIT-I:**

#### **Introduction to Computer Vision:**

Introduction and Goals of Computer Vision and Image Processing, Fundamentals of Image processing, Digital images and pixels, Image formation, sampling, and quantization, 2-D Projective Geometry, 2D transformations: translation, rotation, scaling, affine, and projective, homography (definition, computation, and geometric interpretation), and Properties of homography.

### **UNIT-II:**

#### **Camera and Stereo Geometry:**

Camera Geometry, camera model, Intrinsic and extrinsic parameters, Camera calibration, Stereo Geometry, Epipolar geometry, Fundamental and essential matrices, Rectification and disparity maps, 3D reconstruction from stereo images

### **UNIT-III:**

#### **Image Features and Matching Techniques:**

Feature Detection and Description, Corner detection, Blob detection (LoG, DoG), SIFT, SURF, ORB descriptors, Feature Matching and Model Fitting, Feature matching using distance metrics, Outlier rejection using RANSAC, Transformation estimation (homography, affine)

### **UNIT-IV:**

#### **Color and Range Image Processing:**

Color Processing, Color spaces (RGB, HSV, Lab), Color constancy and correction, Applications in object recognition, Range Image Processing, Depth sensing techniques (stereo, structured light, ToF), Point cloud generation and processing, Surface normal estimation.

### **UNIT-V:**

**Machine Learning in Computer Vision:** Clustering and Classification, means, hierarchical clustering, SVM, k-NN, decision trees, Cross-validation and performance metrics, Dimensionality Reduction and Sparse Representation, PCA, LDA, Dictionary learning and sparse coding

#### **Deep Neural Architectures and Applications:**

Convolutional Neural Networks (CNNs), Object detection and segmentation, Applications in modern computer vision

### **Text Books:**

1. Computer Vision-A Modern Approach, Forsyth & Ponce, Pearson Education.
2. Computer Vision and Image Processing: Fundamentals and Applications”, CRC Press, M.K. Bhuyan, USA, ISBN 9780815370840 - CAT# K338147.
3. Computer Vision- Algorithms & Applications, Richard Szeliski Springer.

**Reference Books:**

1. Multiple View Geometry in Computer Vision: R. Hartley and A. Zisserman, Cambridge University Press.
2. Computer Vision: Algorithms & Applications, R. Szeliski, Springer.
3. Computer vision: A modern approach: Forsyth and Ponce, Pearson.

**Weblinks:**

1. [https://onlinecourses.nptel.ac.in/noc24\\_ee38/preview](https://onlinecourses.nptel.ac.in/noc24_ee38/preview) - Computer Vision and Image Processing - Fundamentals and Applications, by Prof. M. K. Bhuyan, IIT Guwahati.
2. [Computer Vision - Course](#)