# Department of Electrical and Electronic Engineering (EEE)

# University of Dhaka

**The framework of the semester system:**

## <u>Program:</u> M.Sc. Engg. in EEE

- ✓ **Admission: Students will be admitted to the department as per university rules.**
- ✓ **Duration :** 1.5 years.
- ✓ **Total Number of Semesters:** 3 (2 Semesters per year)

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| **Class:** | 14 weeks (3 class hours per week for each course) |
| **Preparation Leave (PL):** | 02 weeks |
| **Exam:** | 03 weeks |
| **Results:** | 03 weeks |
| **Total:** | 22 weeks per semester |

- ✓ **Total Credits in 3 semesters (1.5 years): 36**

## Introduction and Course Identification:

M.Sc. students of different semesters of this department have to follow the course schedule given. Each course is designated by a two to three letter word identifying the department (details described earlier) which offers it followed by a four digit number with the following criteria:

- The **first digit** corresponds to the **year** in which the course is taken by the student.
- The **second digit** represents the **specialized group** in which the course is taken by the student.
- The **third and fourth digit** is reserved for **course serial number of specialized group**.

The second digit of the course number has the following meaning:

- **Digit** 0 is for Thesis/Project/Practical
- 1 for Applied Physics and Material Science Group
- 2 for Instrumentation and Control Group
- 3 for Communication and Signal Processing Group
- 4 for Power System Group

***The minimum credits to be completed for obtaining the degree of M.Sc. Engg in Electrical and Electronic Engineering are 36***

## Teaching of the courses:

- For each credit of a theory course, there will be 1 class per week of 1 hour duration.
- Total classes in a semester for each credit of a theory course will be 15 (15x1).
- Total Contact Hours in a semester for each 1.0 credit theory course: 15x1=15.
- For each 1.0 credit lab course, there will be 1 class per week of 2 hours duration.
- Total classes in a semester for each 1.0 credit lab course in 15 weeks: 15x1=15.

- Total Contact Hours in a semester for each 1.0 credit lab course: 15x2=30.

## Evaluation of the courses:

As per university rule

## Grading System:

The current UGC approved grading system applies as per university rules.

| Marks | Letter Grade | Grade Point |
|---|---|---|
| *80% and Above* | *A+* | *4.00* |
| *75% to 80%* | *A* | *3.75* |
| *70% to < 75%* | *A-* | *3.50* |
| *65% to < 70%* | *B+* | *3.25* |
| *60% to < 65%* | *B* | *3.00* |
| *55% to < 60%* | *B-* | *2.75* |
| *50% to < 55%* | *C+* | *2.50* |
| *45% to < 50%* | *C* | *2.25* |
| *40% to < 45%* | *D* | *2.00* |
| *Less Than 40%* | *F* | *0.00* |

## Marks Distribution:

✓ **For a theory course:**

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|---|---|---|
| **i.** | Attendance | 05% |
| **ii.** | Assignment/Presentation | 05% |
| **iii.** | Incourse | 30% |
| **iv.** | Final Examination | 60% |
| | **Total Marks** | **100%** |

✓ **For a lab course:**

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|---|---|---|
| **i.** | Attendance | 10% |
| **ii.** | Reports | 20% |
| **iii.** | Continuous Assessment | 50% |
| **iv.** | Viva | 20% |
| | **Total Marks** | **100%** |

## Attendance:

Students with **75% attendance and above** in each course will be eligible to sit for the semester final examinations. Students having attendance **>=60% and <75%** will be considered to sit for the examination after paying the some required fines. ***Students having attendance below 60% will not be eligible to appear at the examination***. The marks distribution for attendance is given below:

| Attendance | Marks |
|---|---|
| *90% and Above* | *5.0%* |
| *85% to < 90%* | *4.5%* |
| *80% to < 85%* | *4.0%* |
| *75% to < 80%* | *3.5%* |
| *70% to < 75%* | *3.0%* |
| *65% to < 70%* | *2.5%* |
| *60% to < 65%* | *2.0%* |
| *Less Than 60%* | *0.0%* |

## Rules for Course Taking:

- ✓ There will be four specialized major groups.
- ✓ Each student need to take two courses from his major group and two courses form minor group in a semester.
- ✓ Thesis and Project need to be submitted in third semester.

## The semester-wise distribution of credits of different years is listed below:

## 1.5 Year Distribution

| **M.Sc Engg in EEE** | **1st Semester** | **2nd Semester** | **3rd Semester** | **Total Credit** | **Major** |
|---|---|---|---|---|---|
| Thesis Group | Core Course: 2 courses Optional Course: 2 courses | Core Courses: 2 courses Optional Courses: 2 courses | Thesis: 12 Credits | 36 | 4 |
| Project Group | Core Course: 2 courses Optional Course: 2 courses | Core Courses: 2 courses Optional Courses: 2 courses | Lab: 6 credits Project: 6 credits | 36 | 4 |

## The group wise distribution of credits of different courses is listed below:

There will be four major groups.

Group 1: Applied Physics and Material Science

Group 2: Instrumentation and Control

Group 3: Communication and Signal Processing

Group 4: Power System

**Applied Physics and Material Science Group**

| Course Code | Course Title | Credits |
|---|---|---|
| EEE-5101 | Quantum Mechanics-I | 3 |
| EEE-5102 | Quantum Mechanics-II | 3 |
| EEE-5103 | Classical Mechanics | 3 |
| EEE-5104 | Statistical Mechanics | 3 |
| EEE-5105 | Electrodynamics | 3 |
| EEE-5106 | Solid State Physics | 3 |
| EEE-5107 | Nonlinear Optics | 3 |
| EEE-5108 | Quantum Optics | 3 |
| EEE-5109 | Simulation Modeling in Material Science | 3 |
| EEE-5110 | Nanomaterial | 3 |
| EEE-5111 | Optical Integrated Circuit | 3 |
| EEE-5112 | Surface Engineering | 3 |
| EEE-5113 | Laser Physics | 3 |
| EEE-5114 | Material Structure Science | 3 |
| EEE-5115 | Characterization of Materials and Semiconductors | 3 |
| EEE-5116 | Quantum Computation and Information | 3 |
| EEE-5117 | Cosmology and Gravitation | 3 |
| EEE-5118 | Quantum Field Theory | 3 |
| EEE-5119 | Biophysics | 3 |

**Instrumentation and Control Group**

| | | |
|---|---|---|
| 01. | *EEE-5201* Biomedical Instrumentation | 3 |
| 02. | *EEE-5202* Medical Physics | 3 |
| 03. | *EEE-5203* Geophysics and Instrumentation | 3 |
| 04. | *EEE-5204* Environmental Instrumentation and GIS | 3 |
| 05. | *EEE-5205* Industrial Process Instrumentation and PLC | 3 |
| 06. | *EEE-5206* Multivariate and Adaptive Control System | 3 |
| 07. | *EEE-5207* Fuzzy Neural Control System | 3 |
| 08. | *EEE-5208* Industrial Quality Control | 3 |
| 09. | *EEE-5209* Robotics and Embedded System | 3 |
| 10. | *EEE-5210* Robotics and Automation | 3 |
| 11. | *EEE-5211* Intelligent System | 3 |

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| 12. | *EEE-5212* Mechatronics System Engineering | 3 |
| 13. | *EEE-5213* Multivariable Adaptive Control System | 3 |
| 14. | *EEE-5214* Optical Control Theory | 3 |

**Communication and Signal Processing Group**

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|---|---|---|
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| 01. | *EEE-5301* Advanced Digital Signal Processing | 3 |
| 02. | *EEE-5302* Digital Image Processing | 3 |
| 03. | *EEE-5303* Advanced Digital Image Processing | 3 |
| 04. | *EEE-5304* Computer Vision | 3 |
| 05. | *EEE-5305* Biomedical Signal Analysis and Telemedicine | 3 |
| 06. | *EEE-5306* Video Processing and Coding Technology | 3 |
| 07. | *EEE-5307* Random Signal and Process | 3 |
| 08. | *EEE-5308* Information Theory and Coding | 3 |
| 09. | *EEE-5309* Traffic Theory and Queuing System | 3 |
| 10. | *EEE-5310* Network and Information Security | 3 |
| 11. | *EEE-5311* Digital Speech Processing | 3 |
| 12. | *EEE-5312* High Speed Computer Networking | 3 |
| 13. | *EEE-5313* Advanced Data and Mobile Communication | 3 |
| 14. | *EEE-5314* Advanced Communication Theory | 3 |
| 15. | *EEE-5315* MIMO Wireless Communication | 3 |

**Power System Group**

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|---|---|---|
| | | |
| 01. | *EEE-5401* Power Plant Engineering | 3 |
| 02. | *EEE-5402* Power System Analysis | 3 |
| 03. | *EEE-5403* Power System Operation and Control | 3 |
| 04. | *EEE-5404* Power Electronics | 3 |
| 05. | *EEE-5405* Power System Stability | 3 |
| 06. | *EEE-5406* Electrical Distribution Systems | 3 |
| 07. | *EEE-5407* AI Application to Power Systems | 3 |
| 08. | *EEE-5408* Advanced Power System Protection | 3 |
| 09. | *EEE-5409* Power System Planning and Reliability | 3 |
| 10. | *EEE-5410* Power System Instrumentation | 3 |

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| 11. | *EEE-5411* | Economics and Planning of Energy Systems | 3 |
| 12. | *EEE-5412* | Power System Transients and High Voltage Engineering | 3 |
| 13. | *EEE-5413* | Smart Grid Design and Analysis | 3 |
| 14. | *EEE-5414* | Power Conversion Techniques | 3 |
| 15. | *EEE-5415* | Power System Dynamics | 3 |
| 16 | *EEE-5416* | Renewable Power Generation Sources | 3 |
| 17 | *EEE-5417* | Communication for Power System Operation and Management | 3 |

**Thesis/Project/Laboratory Code**

| | | | |
|---|---|---|---|
| 01. | *EEE-5000* | Thesis | 12 |
| 02. | *EEE-5001* | Project | 6 |
| 03. | *EEE-5002* | Laboratory | 6 |

# Course Contents:

## *Group: Applied Physics and Material Science*

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|---|---|---|
| **EEE-5101** | **Quantum Mechanics-I** | **3 Credits, 3 hours/week** |

**1. Introduction:** Empirical basis, wave-particle duality, electron diffraction, notion of state vector and its probability interpretation.

**2. Structure of Quantum Mechanics:** Operators and observables, significance of eigenfunctions and eigenvalues, commutation relations, uncertainty principle, measurement in quantum theory.

**3. Quantum Dynamics:** Time-dependent Schrödinger equation, stationary states and their significance, time-independent Schrödinger equation.

**4. One-dimensional Schrödinger Equation:** Free-particle solution, wave packets, particle in a square well potential, transmission through a potential barrier, simple harmonic oscillator by wave equation and operator methods, charged particle in a uniform magnetic field, coherent states.

**5. Spherically Symmetric Potentials:** Separation of variables in spherical polar coordinates, orbital angular momentum, parity, spherical harmonics, free particle in spherical polar coordinates, square well potential, hydrogen atom.

**References:**


- L.I. Schiff, Quantum Mechanics.
- E. Merzbacher, Quantum Mechanics.

- R.P. Feynman, Feynman Lectures on Physics (Volume 3).

| EEE-5102 | Quantum Mechanics-II | 3 Credits, 3 hours/week |
|---|---|---|

**1. Symmetry in Quantum Mechanics:** Symmetry operations and unitary transformations, conservation principles, space and time translations, rotation, space inversion and time reversal, symmetry and degeneracy.

**2. Angular Momentum:** Rotation operators, angular momentum algebra, eigenvalues of J2 and Jz, spinors and Pauli matrices, addition of angular momenta.

**3. Identical Particles:** Indistinguishability, symmetric and antisymmetric wave functions, incorporation of spin, Slater determinants, Pauli exclusion principle.

**4. Time-independent Approximation Methods:** Non-degenerate perturbation theory, degenerate case, Stark effect, Zeeman effect and other examples, variational methods, WKB method, tunnelling.

**5. Time-dependent Problems:** Schrödinger and Heisenberg picture, time-dependent perturbation theory, transition probability calculations, golden rule, adiabatic approximation, sudden approximation, beta decay as an example.

**6. Scattering Theory:** Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.

**References:**

- A. Messiah, Quantum Mechanics (Volume II).
- S. Flügge, Practical Quantum Mechanics.
- J.J. Sakurai, Modern Quantum Mechanics.


| EEE-5103 | Classical Mechanics | 3 Credits, 3 hours/week |
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**1. Lagrangian and Hamiltonian Formulations of Mechanics:** Calculus of variations, Hamilton's principle of least action, Lagrange's equations of motion, conservation laws, systems with a single degree of freedom, rigid body dynamics, symmetrical top, Hamilton's equations of motion, phase plots, fixed points and their stabilities.

**2. Two-Body Central Force Problem:** Equation of motion and first integrals, classification of orbits, Kepler problem, scattering in central force field.

**3. Small Oscillations:** Linearization of equations of motion, free vibrations and normal coordinates, forced oscillations.

**4. Special Theory of Relativity:** Lorentz transformation, relativistic kinematics and dynamics, E=mc2.

**5. Hamiltonian Mechanics and Chaos:** Canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action-angle variables, perturbation theory, integrable systems, introduction to chaotic dynamics.

**References:**

- H. Goldstein, Classical Mechanics.
- L.D. Landau and E.M. Lifshitz, Mechanics.
- E.T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies.


| EEE-5104 | Statistical Mechanics | 3 Credits, 3 hours/week |
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**1. Elementary Probability Theory:** Binomial, Poisson and Gaussian distributions, central limit theorem.

**2. Review of Thermodynamics:** Extensive and intensive variables, laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material.

**3. Formalism of Equilibrium Statistical Mechanics:** Concept of phase space, Liouville's theorem, basic postulates of statistical mechanics, ensembles: microcanonical, canonical, grand canonical, and isobaric, connection to thermodynamics, fluctuations, applications of various ensembles, equation of state for a non-ideal gas, Van der Waals' equation of state, Meyer cluster expansion, virial coefficients.

**4. Quantum Statistics:** Fermi-Dirac and Bose-Einstein statistics. Applications of the formalism to:

(a) Ideal Bose gas, Debye theory of specific heat, properties of black-body radiation, Bose- Einstein condensation, experiments on atomic BEC, BEC in a harmonic potential.

(b) Ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat, white dwarf stars.

**5. Nonequilibrium Systems:** Systems out of equilibrium, kinetic theory of a gas, approach to equilibrium and the H-theorem, Boltzmann equation and its application to transport problems, master equation and irreversibility, simple examples, ergodic theorem. Brownian motion, Langevin equation, fluctuation-dissipation theorem, Einstein relation, Fokker-Planck equation.

**6. Ising Model:** Ising model, mean-field theory, exact solution in one dimension, renormalization in one dimension.

**References:**


- F. Reif, Fundamentals of Statistical and Thermal Physics
- K. Huang, Statistical Mechanics.
- R.K. Pathria, Statistical Mechanics.
- D.A. McQuarrie, Statistical Mechanics.


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| **EEE-5105** | **Electrodynamics** | **3 Credits, 3 hours/week** |

**1. Electrostatics:** Differential equation for electric field, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems, examples of image method and Green's function method, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions, dielectrics, polarization of a medium, electrostatic energy.

**2. Magnetostatics:** Biot-Savart law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions, examples of magnetostatic problems, Faraday's law of induction, magnetic energy of steady current distributions.

**3. Maxwell's Equations:** Displacement current, Maxwell's equations, vector and scalar potentials, gauge symmetry, Coulomb and Lorentz gauges, electromagnetic energy and momentum, conservation laws, inhomogeneous wave equation and Green's function solution.

**4. Electromagnetic Waves:** Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities.

**5. Radiation:** Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, antenna, radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.

**6. Covariant Formulation of Electrodynamics:** Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.

**7. Concepts of Plasma Physics:** Formation of plasma, Debye theory of screening, plasma oscillations, motion of charges in electromagnetic fields, magneto-plasma, plasma confinement, hydromagnetic waves.

**References:**


- J.D. Jackson, Classical Electrodynamics.
- D.J. Griffiths, Introduction to Electrodynamics.
- J.R. Reitz, F.J. Milford and R.W. Christy, Foundations of Electromagnetic Theory.


| **EEE-5106** | **Solid State Physics** | **3 Credits, 3 hours/week** |
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**1. Dielectric Properties of Solids:** Dielectric constant of metal and insulator using phenomenological theory (Maxwell's equations), polarization and ferroelectrics, inter-band transitions, Kramers-Kronig relations, polarons, excitons, optical properties of metals and insulators.

**2. Transport Properties of Solids:** Boltzmann transport equation, resistivity of metals and semiconductors, thermoelectric phenomena, Onsager coefficients.

**3. Many-electron Systems:** Sommerfeld expansion, Hartree-Fock approximation, exchange interactions, concept of quasi-particles, introduction to Fermi liquid theory, screening, plasmons.

**4. Introduction to Strongly Correlated Systems:** Narrow band solids, Wannier orbitals and tight-binding method, Mott insulator, electronic and magnetic properties of oxides, introduction to Hubbard model.

**5. Magnetism:** Magnetic interactions, Heitler-London method, exchange and superexchange, magnetic moments and crystal-field effects, ferromagnetism, spin-wave excitations and thermodynamics, antiferromagnetism.

**6. Superconductivity:** Basic phenomena, London equations, Cooper pairs, coherence, Ginzburg-Landau theory, BCS theory, Josephson effect, SQUID, excitations and energy gap, magnetic properties of type-I and type-II superconductors, flux lattice, introduction to high-temperature superconductors.

**References:**

- N.W. Ashcroft and N.D. Mermin, Solid State Physics.
- D. Pines, Elementary Excitations in Solids.
- S. Raimes, The Wave Mechanics of Electrons in Metals.
- M. Tinkham, Introduction to Superconductivity.
- M. Marder, Condensed Matter Physics.


| **EEE-5107** | **Non-linear optics** | **3 Credits, 3 hours/week** |
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**1. Maxwell's equations:** Reflection and refraction at boundaries, Guided waves

**2. Waveguides:** Step-Index Thin-film Waveguides, Three-Dimensional Waveguides, High Index Contrast

Waveguides, Optical Directional Couplers.

**3. Nonlinear optical susceptibility:** Nonlinear optics (NLO), Nonlinear optical processes, Nonlinear susceptibility definition and its properties, Time domain description, Kramers-Kronig relations in linear and nonlinear optics.

**4. Wave equations:** Wave equations for nonlinear optical media, Coupled-wave equations, Phase matching, Quasi-phase-matching, Manley-Rowe relations, Sum-frequency generation, Second harmonic generation, Optical parametric oscillators, Electro-optic (Pockels) effect.

**5. Second order NLO-$\chi^{(2)}$ materials and devices:** Perovskite crystals, Poled polymers, Quasiphasematched (QPM) waveguide frequency doublers, Optical parametric waveguide devices, Integrated electro-optic (IEO) Mach-Zehnder modulators, IEO directional coupler switches.

**6. Third order susceptibility-$\chi^{(3)}$:** Wave equation, Tensor nature, Third harmonic generation (THG), Degenerate four-wave mixing (DFWM), Nondegenerate four-wave mixing (NDFWM), Self-focusing, Self-phase modulation (SPM), Cross phase modulation (XPM), Optical Kerr effect (OKE), D.C. Kerr effect, Nonlinear absorption, Complex $\chi^{(3)}$: Brillouin scattering, Complex $\chi^{(3)}$: Raman scattering, $\chi^{(3)}$ materials: Glasses, Semiconductors, Organic/Polymeric.

**7. Nonlinear effects:** Non-linear effects in optical fibers including self-phase modulation, nonlinear wave propagation, and solitons. Interaction of light with matter, laser operation, density matrix techniques, nonlinear spectroscopies, and femtosecond optics.

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| **EEE-5108** | **Quantum optics** | **3 Credits, 3 hours/week** |

1. Review of Quantum Mechanics, quantization of EM field.

2. Quantum theory of optical coherence: Eigen states of the annihilation operator and minimum uncertainty states, Displaced vacuum states, Wave packets and time evolution, Generation of coherent states, Properties of coherent states, Quantum entanglement: Generation and detection of entangled states.

3. Squeezed state physics, Squeezed states and the uncertainty relation, The squeeze operator and the squeezed coherent states, Multi-mode squeezing.

4. Quantum Interferometry: Michelson interferometer, Sagnac ring interferometer, etc., Photon detection and quantum coherence functions, First-order coherence, Second-order coherence, Photon counting and photon statistics, Multi-photon interferometry.

5. Atom-field interactions, Interaction of an atom with a classical field and with a quantized field, The Rabi model, Quantum-mechanical model, The dressed states, Interaction of two level atom with a quantized EM field: Cavity quantum electrodynamics (CQED), high-Q micro-cavity.

6. Lasing without inversion and other effects of atomic coherence and interference.

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| **EEE-5109** | **Simulation modeling in Material Science** | **3 Credits, 3 hours/week** |

Monte Carlo methods, molecular dynamics, simulation methods for the Ising model and atomic fluids, simulation methods for quantum-mechanical problems, time-dependent Schrödinger equation, discussion of selected problems in percolation, cellular automata, nonlinear dynamics, traffic problems, diffusion-limited aggregation, celestial mechanics, etc.

**References:**


- W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in FORTRAN 77: The Art of Scientific Computing. (Similar volumes in C, C++.)
- D.W. Heermann, Computer Simulation Methods in Theoretical Physics.

- J.M. Thijssen, Computational Physics.

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| **EEE-5110** | **Nanomaterial** | **3 Credits, 3 hours/week** |

**1. Introduction to Nanomaterials:** classification, size-dependent properties of materials, physical chemistry of solid surfaces, surfacre energy & other concepts.

**2. Nanomaterials properties:** mechanical, thermal, electrical, magnetic, optical and acoustic properties. Electronic structure of nanomaterials.

**3. 0D nanomaterials:** naoparticles, 1D nanostructures: nanowires and nanorods, 2D nano structures: thin films. Special nanomaterials: carbon as a nanomaterial, structure of carbon, CNT: their mechanical and electrical properties, SWNT, DWNT and MWNT.

**4. Synthesis:** nanomaterials synthesis process, fabrication, methods of nanoprofiling and characterization of Nanomaterials.

**5. Nanomaterials production:** characterizing forms and functions, functional characteristics, nanoproduct forms: nanocoatings, multilayers and nanofilms, nanopaints and nanosealants, nanoadhesives, nanoporous materials, nanotextiles, nanocosmetics.

**6. Solution chemistry of nanomaterials:** Adsorption in nanoporous materials, Nanoporous catalytic materials. Nanostructured fuel cells and solar cells.

**7. Nanomaterials in health concern:** medical and pharmaceutical context.

**8. Nanomaterials in environmental concern:** water cleaning, air cleaning and soil remediation.
Toxicity of Nanomaterials: current approaches in hazard assessment and research activity.

**9. Electronic transport in mesoscopic systems**

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| **EEE-5111** | **Optical Integrated Circuits** | **3 Credits, 3 hours/week** |

**1. Optical properties** of materials for integrated optoelectronics (IO) and photonics (IP), advantage of optical integrated circuits (OICs), passive optical structures and devices for integrated optics.

**2. Types of optical waveguides,** materials and optical waveguide fabrication techniques, design of OIC elements (optical switch, optical directional coupler, light divider, light combiner, optical polarizer, and optical isolator), optoelectronic modulators- electro-optically controlled devices properties and technology.

**3. Limitations of miniaturization,** exact analysis of guided beam in OICs, Some numerical techniques of OICs (Finite element method - FEM, Beam propagation method - BPM, finite difference method – FDM).

**4. Semiconductor materials and structures** applicable for integrated optoelectronics. Active semiconductor devices based on heterostructures, quantum wells and superlattices applicable for integrated optoelectronics. Integrated optoelectronic transmitters and receivers for optical communication systems. Integrated optoelectronic optical systems for recording, processing and display the information.

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| **EEE-5112** | **Surface Engineering** | **3 Credits, 3 hours/week** |

**1. Semiconductor surface theory concepts:** surface potential in equilibrium, threshold voltage under nonequilibrium conditions, channel charge under strong inversion in non-equilibrium, Silicon surface charges and states, radiation effects, impurity redistribution at the oxidized silicon surface.

**2. Surface plasmas** (propagation at metal-dielectric interfaces, transmission through subwavelength hole, subwavelength waveguides).

**3. Surface effects:** surface EM wave, surface polaritons, size dependence.

**4. Physical vapour deposition technologies:** ion plating, sputter deposition, reactive deposition, magnetron sputtering, general aspects of PVD (production sequence, advantages and disadvantages, microstructure), partial pressure control, summary of applications, duplex treatments.

**5. Surface spectroscopies and instrumentation:** surface structure, LEED, RHEED, SPM (STM, AFM, etc.), X-ray photoelectron spectroscopy (XPS, A.K.A. ESCA), Auger electron spectroscopy (AES), Secondary ion mass spectrometry (SIMS), Rutherford backscattering spectrometry (RBS).

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| **EEE-5113** | **Laser Physics** | **3 Credits, 3 hours/week** |

**1. Basic concepts of energy-level** manifolds in gain media, particularly in respect of population inversion and saturation effects; conditions for oscillator stability in laser resonator configurations and transverse and longitudinal cavity mode descriptions; single longitudinal mode operation for spectral purity and phase locking of longitudinal modes for the generation of periodic sequences of intense ultrashort pulses (i.e. laser modelocking); illustrations of line-narrowed and modelocked lasers and the origin and exploitability of intensity-induced optical effects.

**2. Transient/dynamic behaviour of laser oscillators** including relaxation oscillations, amplitude and hase modulation, frequency switching, Q-switching.

**3. Cavity dumping and mode locking;** design analysis of optically-pumped solid state lasers; laser amplifiers including continuous-wave, pulsed and regenerative amplification; dispersion and gain in a laser oscillator-role of the macroscopic polarization; unstable optical resonators, tunable lasers.

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| **EEE-5114** | **Material Structure Science** | **3 Credits, 3 hours/week** |

**1. Properties of X-rays:** Characteristic spectrum, Absorption, Filters, Production of X-rays, Detection of X-rays.

**2. Geometry of Crystals:** Crystal systems, symmetry, Primitive and non-primitive cells lattice directions and planes, crystal structure.

**3. Diffraction I:** Diffraction, Bragg law, X-ray spectroscopy, Diffraction directions, Diffraction methods, Nonideal conditions.

**4. Diffraction II:** Scattering by an electron, atom and unit cell, Structure factor calculation; Multiplicity, Lorentz, absorption and temperature factor, Intensities of powder pattern lines.

**5. Diffractometer and Spectrometer measurements:** counters, proportional counters, Geiger counters, Scintillation counters, Semiconductor counters Pulse-height analysis, Energy-dispersive and time-analysis diffractometry.

**6. Determination of Crystal Structure:** Treatment of data, Indexing patterns, Effect of cell distortion, Determination of number of atoms in unit cell and atom positions.

**7. Order-disorder Transformations:** Long-range order in $AuCu_3$, Detection of super lattice lines, Short-range order and clustering.

**References:**


- Elements of X-ray Diffraction, Author: B.D. Cullity, Publisher: Addison-Wesley Publication Company, Inc.

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| **EEE-5115** | **Characterization of Materials and Semiconductors** | **3 Credits, 3 hours/week** |

**1. Aspects of materials characterization:** structural characterization, chemical characterization, surface (topographical) characterization, mechanical (hardness and elastic modulus) characterization.

**2. Crystallography:** elementary crystallography, symmetry elements and operations, point groups, space groups, reciprocal space, stereographic projection.

**3. Scattering and diffraction:** production, characteristics and detection of X-rays, scattering and diffraction, reciprocal space and diffraction, diffraction methods, structure factor, diffraction intensity.

**4. X-ray Diffraction:** phase diagram determination, order-disorder transformations, powder diffraction file (PDF) database, peak broadening, quantitative phase measurement by X-ray diffraction, preferred orientation (texture) in materials, residual stress measurement.

**5. Scanning and transmission electron microscopies:** scanning electron microscopy (SEM), chemical analysis on the SEM, transmission electron microscopy (TEM), TEM sample preparation, scanning tunneling microscopy (STM).

**6. Spectroscopy:** introduction to various spectroscopic techniques, energy dispersive spectroscopy (EDS), wavelength dispersive spectroscopy (WDS), X-ray photoelectron spectroscopy (XPS), X-ray fluorescence (XRF), optical emission spectroscopy (OES), mass spectroscopy and secondary ion mass spectrometry (SIMS), photoluminescence and electroluminescence characterization techniques, Raman spectroscopy.

**7. Other characterization techniques:** scanning probe microscopy (SPM), surface analysis- atomic force microscopy, profilometry, magnetic force microscopy (MFM), ion sputtering method for material characterization, Auger electron spectroscopy, low energy loss spectroscopy, deep level transient spectroscopy (DLTS), CV measurement system for bulk and quantum well, focused ion beam etching for smooth surface, thermal analysis: DTA, DSC, ESCA.

**8. Characterization tools for solar cell.**

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| **EEE-5116** | **Quantum Computation and Information** | **3 Credits, 3 hours/week** |

**1. Introduction to quantum mechanics:** Hilbert space, Unitary and stochastic dynamics, Probabilities and measurements, Entanglement, Density operators and correlations, Quantum computation: Single Qubit operations, Controlled operations, Universal quantum gates, Quantum circuit model, Simulation of quantum systems, Quantum Fourier transform and its application.

**2. Different quantum computers:** Physical realization

**3. Quantum algorithms:** Classical computation, Shor factorization, Grover search, Measurement-based computation

**4. Quantum information**: Classical information theory, Quantum information types and quantum channels, Dense coding, Teleportation, No cloning, Quantum cryptography

**5. Quantum Noise and quantum operations:** Classical noise and Markov processes, Quantum operations, Examples of quantum Noise and quantum operations, Applications of quantum operations, Limitations of the quantum operations formalism.

**6. Quantum error correction:** Graph states and codes, The Shor code, Quantum error correction, Fault-tolerant computation

**7. Quantum information theory:** Data compression, Quantum cryptography.

| EEE-5117 | Cosmology and Gravitation | 3 Credits, 3 hours/week |
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**1. Physics of the Universe:** Astronomical observations and instruments, stellar spectra and structure, stellar evolution, nucleosynthesis and formation of elements, evolution and origin of galaxies, quasars, pulsars, expansion of the universe, big-bang model, CMBR, anisotropy.

**2. General Relativity:** Review of special theory of relativity, four-vector formulation of Lorentz transformation, covariant formulation of physical laws, introduction to general relativity, principle of equivalence, tensor analysis and Riemannian geometry, curvature and stress-energy tensors, gravitational field equations, geodesics and particle trajectories, Schwarschild solution, Kerr solution, gravitational waves, relativistic stellar structure, TOV equation, basic cosmology.

**References:**


- K.D. Abhyankar, Astrophysics: Stars and Galaxies.
- J.V. Narlikar, An Introduction to Cosmology.
- C.W. Misner, K. Thorne, J.A. Wheeler, Gravitation.
- R. Adler, M. Bazin and M. Schiffer, Introduction to General Relativity.
- T. Padmanabhan, Cosmology and Astrophysics through Problems.


| EEE-5118 | Quantum Field Theory | 3 Credits, 3 hours/week |
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**1. String waves, water waves,** etc. as examples of classical fields, Lagrangian and Hamiltonian formulation of a vibrating string fixed at both ends in analogy with Newtonian particles.

**2. Relativistic kinematics,** relativistic waves, Klein-Gordon (KG) equation as a relativistic wave equation, treatment of the KG equation as a classical wave equation: its Lagrangian and Hamiltonian, Noether's theorem and derivation of energy-momentum and angular momentum tensors as consequence of Poincaré symmetry, internal symmetry and the associated conserved current.

**3. Canonical quantization of the KG field,** solution of KG theory in Schrödinger and Heisenberg pictures, expansion in terms of creation and annihilation operators, definition of the vacuum and N-particle eigenstates of the Hamiltonian, vacuum expectation values, propagators, spin and statistics of the KG quantum.

**4. Review of Dirac equation and its quantization,** use of anti-commutators, creation and destruction operators of particles and antiparticles, Dirac propagator, energy, momentum and angular momentum, spin and statistics of Dirac quanta.

**5. Review of free Maxwell's equations,** Lagrangian, gauge transformation and gauge fixing, Hamiltonian, quantization in terms of transverse delta functions, expansion in terms of creation operators, spin, statistics and propagator of the photon.

**6. Introduction to interacting quantum fields.**

**References:**


- C. Itzykson and J.-B. Zuber, Quantum Field Theory.
- J.D. Bjorken and S.D. Drell, Relativistic Quantum Fields.
- L. Ryder, Quantum Field Theory.

| EEE-5119 | **Biophysics** | **3 Credits, 3 hours/week** |
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**1. Introduction:** Evolution of biosphere, aerobic and anaerobic concepts, models of evolution of living organisms.

**2. Physics of Polymers:** Nomenclature, definitions of molecular weights, polydispersity, degree of polymerization, possible geometrical shapes, chirality in biomolecules, structure of water and ice, hydrogen bond and hydrophobocity.

**3. Static Properties:** Random flight model, freely-rotating chain model, scaling relations, concept of various radii (i.e., radius of gyration, hydrodynamic radius, end-to-end length), end-to-end length distributions, concept of segments and Kuhn segment length, excluded volume interactions and chain swelling, Gaussian coil, concept of theta and good solvents with examples, importance of second virial coefficient.

**4. Polyelectrolytes:** Concepts and examples, Debye-Huckel theory, screening length in electrostatic interactions.

**5. Transport Properties:** (a) Diffusion: Irreversible thermodynamics, Gibbs-Duhem equation, phenomenological forces and fluxes, osmotic pressure and second virial coefficient, generalized diffusion equation, Stokes-Einstein relation, diffusion in three-component systems, balance of thermodynamic and hydrodynamic forces, concentration dependence, Smoluchowski equation and reduction to Fokker-Planck equation, concept of impermeable and free-draining chains.

(b) Viscosity and Sedimentation: Einstein relation, intrinsic viscosity of polymer chains, Huggins equation of viscosity, scaling relations, Kirkwood-Riseman theory, irreversible thermodynamics and sedimentation, sedimentation equation, concentration dependence.

**6. Physics of Proteins:** Nomenclature and structure of amino acids, conformations of polypeptide chains, primary, secondary and higher-order structures, Ramachandran map, peptide bond and its consequences, pH-pK balance, protein polymerization models, helix-coil transitions in thermodynamic and partition function approach, coil-globule transitions, protein folding, protein denaturation models, binding isotherms, binding equilibrium, Hill equation and Scatchard plot.

**7. Physics of Enzymes:** Chemical kinetics and catalysis, kinetics of simple enzymatic reactions, enzyme-substrate interactions, cooperative properties.

**8. Physics of Nucleic Acids:** Structure of nucleic acids, special features and properties, DNA and RNA, Watson-Crick picture and duplex stabilization model, thermodynamics of melting and kinetics of denaturation of duplex, loops and cyclization of DNA, ligand interactions, genetic code and protein biosynthesis, DNA replication.

**9. Experimental Techniques:** Measurement concepts and error analysis, light and neutron scattering, X-ray diffraction, UV spectroscopy, CD and ORD, electrophoresis, viscometry and rheology, DSC and dielectric relaxation studies.

**10. Recent Topics in Bio-Nanophysics.**

**References:**


- M.V. Volkenstein, General Biophysics.
- C.R. Cantor and P.R. Schimmel, Biophysical Chemistry Part III: The Behavior of Biological Macromolecules.


## *Group: Instrumentation and Control*

| EEE-5201 | Biomedical Instrumentation | 3 Credits, 3 hours/week |
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**1. Origin of Biopotential & Electrophysiological signals.**

**2. Biomedical sensors:** Physical measurements, bio-potential Electrodes, electrochemical sensors, optical sensors.

**3. Medical devices and Systems:** Bio-potential amplifiers, Spectral and Non spectral Clinical Instruments. ECG, EMG , EEG machines, Defibrillators.

**4. Medical Imaging Systems:** X-ray Machines, Digital Subtraction Machines, Computed Tomography, Ultrasound systems, MRI Machines, PET , SPECT, Electrical Impedance Imaging systems, Infrared Camera and Devices, Lasers Devices & Systems.

**5. Instruments in Cancer:** Cobalt Machine, Linac, IMRT , Treatment Planning System. Virtual instruments in health care. Risk Factors, Safety and Management of Medical equipment.

**References:**


(1) Medical Devices and Systems, Joseph D Bronzino

(2) Biomedical Instruments , Theory and Desgn: Welkowitz & Akay, Academic Press, 1992

(3) Medical Imaging Signals and systems, Jery l Prine & Jonathan Links, pearson , 2011.

(4) Introduction to Biomedical Equipment Tech., Carr and Brown, Prentice Hall.

(5) Biomedical Instrumentation: Technology and Applications, Khandpur, McGraw Hill.


| EEE-5202 | Medical Physics | 3 Credits, 3 hours/week |
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**1. Health physics:** The fundamental principles and objectives of health physics (radiation protection), the quantities of radiation dosimetry (the absorbed dose, equivalent dose, and effective dose) used to evaluate human radiation risks

**2. Anatomy for physicists and engineers:** Study of the human body from a medical imaging point of view: skeletal, respiratory, cardiovascular, digestive, and urinary systems, breast and women痴 issues, head and neck, and central nervous system

**3. Clinical nuclear medicine physics:** Introduction to the instrumentation and physics used in clinical nuclear medicine and PET with an emphasis on detector systems, tomography and quality control

**4. Radiation therapy physics:** Review of x-ray production and fundamentals of nuclear physics and radioactivity. Detailed analysis of radiation absorption and interactions in biological materials as specifically related to radiation therapy and radiation therapy dosimetry.

**References:**


**Medical Physics and Biomedical Engineering by** B. H. Brown, R. H. Smallwood, D. C. Barber, P. V. Lawford, D. R. Hose


| EEE-5203 | Geophysics & Instrumentation | 3 Credits, 3 hours/week |
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**1. Elements of Geology:** Physical and structural Geology, Mineralogy, Petrology.

**2. Geohydrology:** Elements of Geohydrology, Hydrological properties of water bearing materials, Properties of ground water, Movement of groundwater and aquifer performance tests, Darcy's law and its range of validity, theory of groundwater flow under steady and unsteady conditions, determination of permeability, transmissivity and storativity by discharging methods, Natural and artificial recharge of groundwater, water balance, analysis of hydrograph, conjunctive and consumptive uses of groundwater, staff gage, flow meter, current meter, water quality sonde, tipping bucket raingage.

**3. Meteorology:** Composition and structure of the atmosphere, general circulation of atmosphere, Priciple of weather forecasting, Thermodynamics, Radiation, Wind system, Surface, self-recording and upper air meteorological instruments (mercury and aneroid barometer, barograph, air thermometers, bimetallic thermograph, psychrometer, hairhygrograph, cup anemometer, Dines pressure tube anemograph, ordinary and recordingraingauges, nephoscope, sunshine recorder, pilot balloon, theodolite, radio sonde, rawin and radar).

**4. Geoexploration and surveying:** Basic principle of geophysical exploration, gravity method, electrical method, radiometric method, seismic method, gravimeter, magnetometer, Tagg's method, refraction method for finding depth, theodolite, microptic alidade.

**References:**

1. David Keith Todd, Larry W. Mays, *"Groundwater Hydrology*", 3rd Edition, Wiley.

2. W. M. Telford, L. P. Geldart, R. E. Sheriff, "Applied Geophysics", 2nd Edition, Cambridge University Press.

3. P. Kearey, M. Brooks, I. Hill, "An Introduction to Geophysical Exploration" 3rd Edition, Wiley-Blackwell.

| EEE-5204 | Environmental Instrumentation and GIS | 3 Credits, 3 hours/week |
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**1. Environmental instrumentation:** Spectroanalytical methods- electromagnetic radiation, atomic absorption and emission spectrometry, fluorimetry, nephelometry and turbidimety, ultraviolet-visible spectrophotometry principle and instrumentation, Beer's law. Chromotographic methods-classification, gas chromatography and HPLC, Ion exchange chromatography and size exclusion chromatography, Mass spectrometry. Electro analytical methods- potentiomety, measurement of pH, potentiometric titrations, coulometry and polarography, Radio analytical and other methods- Particles emitted in radioactive decay, measurement of radioactivity, Isotopic dilution analysis and activation analysis. NDIR for CO analysis, Chemiluminescent analyzer for NOx, florescent analyzer for $SO_2$ , flow injection analysis and CHN analyzer.

**2. GIS:** Components of GIS, Hardware, Software and Organization Context, GIS Data, Spatial and Non Spatial, Maps, Projection, Data Input and editing – Digitizer, Scanner, Raster and Vector data structures, Comparison of Raster and Vector Data structure , Analysis using raster and Vector Data - Retrieval , Reclassification , Overlaying, Buffering, Data Output – Printers and Plotters. Integration of GIS and remote sensing- application in environmental engineering.

**References:**

1. D.A.Skoog, D,M, West and T.A Nieman, "*Principles of Instrumental Analysis*", 5th Ed.Thomson Asion (P) Ltd. Singapore, 2004

2. Longley, P.A., Goodchild, M.F., Maguire, D.J., and Rhind, D.W., "*Geographic Information Systems and Science*", 3rd Edition, John Wiley & Sons.

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| **EEE-5205** | **Industrial Process Instrumentation and PLC** | **3 Credits, 3 hours/week** |

*To be briefed in class by course instructor.*

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| **EEE-5206** | **Multivariate and Adaptive Control System** | **3 Credits, 3 hours/week** |

*To be briefed in class by course instructor.*

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| **EEE-5207** | **Fuzzy Neural Control Systems** | **3 Credits, 3 hours/week** |

**1. Introduction to Computational Intelligence,** Paradigms of Computational Intelligence, Computational Intelligence in Control, Introduction to Fuzzy Logic, Fuzzy Sets, Fuzzy Relations, Fuzzification, Defuzzification, Inference Mechanisms, Fuzzy Systems and Applications, Fuzzy Modelling, Design of Fuzzy Controller, Modular Fuzzy Controller.

**2. Introduction Neural Networks,** Models of a Neuron, Network Architectures, Knowledge Representation, Learning Processes, Perceptron, Convergence Theorem, Pattern Classification, Linear Regression Model, Least-Mean-Square Algorithm, Markov Model, The Langevin Equation, Kushner's Direct-Averaging Method

**3. Multilayer Perceptrons**, Batch Learning and On-Line Learning, Back-Propagation Algorithm, Radial-Basis Function Networks Support Vector Machines, Regularization Theory, Semisupervised Learning, Principal-Components Analysis, Self-Organizing Maps,

**4. Information-Theoretic Learning Models,** Statistical Mechanics, Markov Chains, Boltzmann Machine, Dynamic Programming, Neurodynamics Models, Hopfield Model, Recurrent Network Architectures, Real-Time Recurrent Learning, System Identification and Control, Neural Networks for Control

**5. Neural Fuzzy Systems,** Combination of Neural and Fuzzy Systems, Cooperative Neuro-Fuzzy Systems, Concurrent Neuro-Fuzzy Systems, Hybrid Neuro-Fuzzy Systems, Adaptive Neuro-Fuzzy System

**References:**

1. Neural Networks and Learning Machines - by Simon O. Haykin, Prentice Hall, ©2009, ISBN-10: 0131471392 • ISBN-13: 9780131471399

2. Computational Intelligence: Synergies of Fuzzy Logic, Neural Networks and Evolutionary Computing - by Nazmul Siddique, Hojjat Adeli, Publisher: Wiley; 1 edition (May 28, 2013), ISBN: 978-1-118-33784-4

3. Artificial Intelligence: A Guide to Intelligent Systems (3rd Edition) – by Michael Negnevitsky, Publisher: Pearson Education Canada; May 10, 2011, ISBN-13: 978-1408225745

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| **EEE-5208** | **Industrial Quality Control** | **3 Credits, 3 hours/week** |

*To be briefed in class by course instructor.*

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| **EEE-5209** | **Robotics and Embedded Systems** | **3 Credits, 3 hours/week** |

*To be briefed in class by course instructor.*

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| **EEE-5210** | **Robotics and Automation** | **3 Credits, 3 hours/week** |

**1. Introduction to automation and robotics**: Fixed and flexible automation; High speed automation. Social and economic aspects; Safety issues and risk assessment; Future applications.

**2. Machine design**: Degrees of freedom; Actuators and power transmission; End effector design; Robot accuracy.

**3. Machine control**: Feedback control; Servomechanisms; PLC's and fieldbus; Kinematic analysis.

**4. Sensors and Machine vision**: Transducers, tactile and proximity sensors; Vision - image analysis, cameras, optics, lighting and applications.

**5. Robot programming and languages**: Methods of programming; Teach mode, off line, and graphical simulation. Languages, e.g. VAL/V+.

**6. Simulation:** Introduction to Matlab/Simulink simulation, Simulating Mechanical Systems, Simulating Actuators/sensors,

**7. Medical Robotics**: Sensors and actuators relevant to this area of application, intelligent control in Medical Robotics, Artificial Hearts, Active Limb Prostheses, Medical Imaging/ Robotic Surgery

**References:**


1. Introduction to Robotics: Anaylysis, Systems & Applications, by Saeed B. Niku, Wiley; 2nd edition, September 22, 2010.
2. Introduction to robotics : mechanics and control, by John J. Craig, Pearson/Prentice Hall, 2005,
3. Using MATLAB, Simulink, and Control Toolbox : a practical approach, The MathWorks Inc, available on line as pdf, 1996
4. Control systems engineering, NS Nise, 4th edition, Wiley, 2004, ISBN 0471445770
5. Digital control of dynamic systems, G Franklin, J Powell, Workman, 3rd edition, Addison- Wesley, 1998, ISBN 0201820544


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| **EEE-5211** | **Intelligent Systems** | **3 Credits, 3 hours/week** |

**1. Introduction:** Introduction to intelligent system and agent, agent classification.

**2. Solving problems by searching:** state space formulation, depth first and breadth first search, searching with cost, iterative deepening, Heuristic search, A* and its memory restricted variants.

**3. Production systems:** Design implementation and limitations, case studies.

**4. Game Playing**: Minimax, alpha-beta pruning.

**5. Knowledge and reasoning:** Propositional and first order logic, semantic networks, building a knowledge base, inference in first order logic, logical reasoning systems.

**References:**


S Russell and P Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, (Third Edition) 2010.


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| **EEE-5212** | **Mechatronics System Engineering** | **3 Credits, 3 hours/week** |

**1. Overview of Mechatronics,** Mechatronic Design Approach, System Interfacing, Instrumentation and

Control Systems, Microprocessor-Based Controllers and Microelectronics, An Introduction to Micro- and Nanotechnology, New Directions in Nano- Micro-, and Mini-Scale Electromechanical Systems, Design, and Engineering Curriculum Development

2. **Physical System Modeling,** Modeling Electromechanical Systems, Structures and Materials, Modeling of Mechanical Systems for Mechatronics Applications, Fluid Power Systems, Engineering Thermodynamics, Modeling and Simulation for MEMS, Rotational and Translational Microelectromechanical Systems: MEMS Synthesis, Microfabrication, Analysis, and Optimization, The Physical Basis of Analogies in Physical System Models

3. **Sensors and Actuators,** Integrated Micro-sensors, Electro-mechanical Actuators, MEMS: Microtransducers Analysis, Design and Fabrication

4. **Systems and Controls,** Controls in Mechatronics, State Space Analysis and System Properties, Response of Dynamic Systems, Root Locus Method, Frequency Response Methods, Kalman Filters as Dynamic System State Observers, Digital Signal Processing for Mechatronic Applications, Control System Design Via H2 Optimization, Adaptive and Nonlinear Control Design, Design Optimization of Mechatronic Systems

5. **Computers and Logic Systems,** Logic Concepts and Design, System Interfaces, Communication and Computer Networks, Fault Analysis in Mechatronic Systems, Logic System Design, Control with Embedded Computers and Programmable Logic Controllers

6. **Software and Data Acquisition,** Introduction to Data Acquisition, Measurement Techniques: Sensors and Transducers, A/D and D/A Conversion, Signal Conditioning, Computer-Based Instrumentation Systems, Software Design and Development, Data Recording and Logging

7. **Programmable motion control and algorithm development,** Applications: Digital fabrication and 3D printing, Numerical control and CAD/CAM.

**References**

1. G.Genta, *Vibration of structures and machines*, Springer, New York, 1998

2. *Introduction to Mechatronics and Measurement Systems 3rd ed.*, Histand, M. B., Alciatore, D. G., WCB/McGraw-Hill, Boston, 2007, ISBN: 9780072963052.

3. Robert H. Bishop. Editor-in-chief. *"The Mechatronics Handbook"*, CRC Press, with ISA–The Instrumentation, Systems, Automation Society (50 Chapters), 2002. ISBN: 0-8493-0066-5
4. John G. Webster. Editor-in-chief. "*Measurement, Instrumentation, and Sensors Handbook*" CRC Press. 1999. 0-8493-2145-X. PDF files online available at **www.engnetbase.com**

5. Karnopp, D., Margolis, D. and Rosenberg, R., *System Dynamics: Modeling and Simulation of Mechatronic Systems*, Third Edition, Wiley Interscience, 2000.

6. Mechatronics, Sabri Cetinkunt, Wiley, 2006.

7. Fundamentals of Mechatronics, Musa Jouaneh, Cengage Learning, 2011

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| **EEE-5213** | **Multivariable Adaptive Control System** | **3 Credits, 3 hours/week** |

**1. Examples of multivariable control systems,** Mathematical Modeling of Multivariable Systems, State space, polynomial and stable fraction models.

**2. Controllability,** observability and computations involved in their analysis. Realization theory of multivariable systems and algorithms.

**3. Stability by Lyapunov's method,** solution of Lyapunov equations. Pole placement, observer design and stabilization theory.Spectral factorizations of systems. Solution of the Ricatti equation.Balanced realizations and their computations.Mono-variable Control of Multivariable Systems: Single loop control (SLC) and choice of variables for SLC, decoupling

**4. Multivariable Control:** Slow and fast state variables, discrete and continuous controllers, pole placement and feedback control, observer problem

**5. Optimal Control:** Linear quadratic (LQ) criteria, discrete LQ control

**6. Observers:** Model based (Luenberger) observer, stochastic signals: white noise, Kalman filter, Kalman observer- adaptive control

**7. Multivariable Frequency Response**

**8. Adaptive Control:** Introduction , Recursive parameter estimation, Model reference adaptive control, State Feedback Design, Output Feedback Design, Adaptive pole placement control: Scalar Case, Polynomial Approach, State-Variable Approach, Robust adaptive control schemes, Averaging-based analysis, Adaptive control of nonlinear systems, Adaptive Control of Nonlinear Systems, Systems with Deadzone, Backlash or Hysteresis, Adaptive Control via Linearization, Adaptive Control via Backstepping, Repetitive Control

**References:**


1. Anderson and Moore, *Optimal control-Linear quadratic methods,* PHI 1995
2. C.T.Chen : Linear system theory and design, 3rd edition, Oxford 1999.
3. John Bay : Fundamentals of linear state space systems, McGraw Hill, 1998.
4. Wilson Rugh : Linear system theory, 2nd edition, Prentice Hall, 1996.
5. Björn Wittenmark , Karl Johan Åström, **Adaptive control,** 2. ed. Addison-Wesley, 1995.
6. Petros A. Ioannou , Jing Sun, **Robust adaptive control,** Upper Saddle River, N.J. : Prentice Hall International : 1996.


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| **EEE-5214** | **Optical Control Theory** | **3 Credits, 3 hours/week** |

*To be briefed in class by course instructor.*

## *Group: Communication and Signal Processing*

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| **EEE-5301** | **Advanced Digital Signal Processing** | **3 Credits, 3 hours/week** |

**1. Multirate Digital Signal Processing:** Multirate processing, fundamentals of decimation and interpolation, methods for optimizing processing throughput requirements via multirate designs, multirate techniques in filter banks, spectrum analyzers and synthesizers, structures and network theory for multirate digital systems.

**2. Finite Arithmetic Error Analysis:** Analog-to-Digital conversion errors, quantization effects of finite arithmetic for common digital signal processing algorithms including digital filters and FFTs, methods of calculating the noise at the digital system output due to arithmetic effects.

**3. Linear Prediction theory:** Representation of a stationary random process, discrete random signals, moments, bias-variance, linear stochastic models, ARMA (Auto Regressive Moving Average) modeling, properties of estimators bias/variance, Cramer Rao Lower Bound , MVU (Minimum Variance Unbiased) estimator, BLUE (Best Linear Unbiased Estimator), ML (Maximum Likelihood) estimation, Bayesian estimation, Forward and Backward Linear Prediction, Levinson-Durbin Algorithm, Properties of the Linear Predictors, The Concept of a Whitening Filter

**4. Power Spectrum Estimation:** Estimation of Autocorrelation and Power Spectrum of Random Signals, Non Parametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation

**5. Statistical signal processing:** Orthogonality principle, block and sequential forms, Wiener filter, adaptive filtering, Recursive Least Squares Estimation, Kalman Filter Theory, Adaptive Algorithms: LMS, RLS and their variants, Joint Multichannel Least Squares Lattice, Spatial filtering of equally and unequally spaced arrays.

**6. Applications:** Acoustic echo cancellation, signal enhancement, inverse system modelling, denoising.

**References:**


1. Digital Signal Processing: A computer-based approach, Sanjit K. Mitra, McGraw-Hill, 3rd edition, 2005.
2. Digital Signal Processing - Principles, Algorithms and Applications, John G. Proakis and Dimitris G. Manolakis, Macmillan, New York, Third edition,1996.
3. Theory and Application of DSP, L.R. Rabiner and B. Gold.
4. Discrete-Time Signal Processing, Oppenheim, Schafer & Buck, Prentice-Hall, New Jersey, 2nd edition, 1999.
5. Statistical and Adaptive Signal Processing, Manolakis, D., Ingle, M., Kogon, S., McGraw-Hill, 2000.
6. Adaptive Filter Theory, Haykin, S., Prentice Hall, New Jersey, Third edition,1996.
7. Advanced Digital Signal Processing, Proakis, J. G., Rader, C. M., Ling, F., Nikias, C. and L., Macmillan, New York, 1992.
8. Digital Signal Processing: A System Design Approach, DeFatta, D. J., Lucas, J. G., Hodgkiss and W. S., John, Wiley and Sons, New York, 1988.
9. Introductory Digital Signal Processing with Computer Applications, P.A. Lynn, W. Fuerst and B.Thomas, John Wiley.
10. Digital Signal Processing, M.H.Hayes, Schaum's Outline Series, McGraw Hill, 1999.
11. Statistical Signal Processing, Scharf, L. L., Addison-Wesley, 1991.
12. Digital Processing of Random Signals, Porat, B., Prentice Hall, 1994.
13. Adaptive filters: Theory and Applications, B. Farhang-Boroujeny.
14. Fundamentals of Statistical Signal Processing: Estimation Theory, S. Kay, Prentice Hall.
15. *Statistical Digital Signal Processing and Modelling, Monson Hayes, Wiley, 1996.*


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| **EEE-5302** | **Digital Image Processing** | **3 Credits, 3 hours/week** |

Introduction, Image Representation, Brightness adaption and discrimination, Pixels, Coordinate conventions, Imaging Geometry, Perspective Projection, Image acquisition and digitization, Human eyes and visual perception, Intensity Transformations and Spatial Filtering, Filtering in Frequency Domain, Image Transformation: DFT, Hadamar, Haar, DCT, Image Restoration, Image Compression.

**Text book :**

Digital Image Processing, Rafeal C.Gonzalez, Richard E.Woods, Third Edition, Pearson Education.

**References:**


*A. K. Jain*, Fundamentals of Digital Image Processing, Prentice Hall of India, 1989.

| EEE-5303 | Advanced Digital Image Processing | 3 Credits, 3 hours/week |
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**Image Transform:** Wavelets, The basic functions, Continuous wavelet transform (CWT), Discrete wavelet transform (DWT). Wavelet decomposition and reconstruction of functions in *L2(R)*. Construction of wavelets, two dimensional DWT, KLT.
**Image compression**: Fundamental coding theorem, Lossless Compression: Huffman Coding, Arithmetic coding, Bit plane coding, Run length coding, Lossy compression: JPEG, JPEG2000.
**Image Segmentation:** Pixel classification, Point, Line and Edge detection, Thresholding, Region based segmentation, Segmentation using morphological watersheds and motion.
**Object Recognition:** Patterns and patterns classes, recognition based on decision– theoretic methods, matching, optimum statistical classifiers, neural networks, structural methods.
**Color Image Processing:** Color fundamentals, color models, pseudo color image processing, color transforms and segmentation.
**Morphological Image Processing:** Preliminaries, dilation, erosion, open and closing, hit or miss transformation, basic morphologic algorithms.

**Text book :**


1. Digital Image Processing, Rafeal C.Gonzalez, Richard E.Woods, Third Edition, Pearson Education.


**References:**


2. *M. Vetterli, J. Kovacevic*, “Wavelets and subband coding” Prentice Hall Inc, 1995
3. *Gilbert Strang and Truong Q. Nguyen*, “Wavelets and filter banks” 2nd Edition, Wellesley-Cambridge Press, 1998.
4. *Stephen G. Mallat,* “A wavelet tour of signal processing” 2nd Edition Academic Press, 2000.


| EEE-5304 | Computer Vision and Applications | 3 Credits, 3 hours/week |
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Introduction to computer vision, face recognition, linear filters, line detection, detection to model fitting, clustering and segmentation, camera models, camera calibration, stereo and multi-view reconstruction, feature detection, feature descriptors, object recognition, optical flow, tracking, bag-of-words models, object classification and detection, human motion recognition, stereo vision, computer vision and future, implementations with OpenCV.

References:


1. Richard Szeliski, Computer Vision: Algorithms and Applications, Microsoft Research, 2010.
2. Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2002.
3. Adrian Kaehler, Gary Bradski, Learning OpenCV: Computer Vision in C++ with the OpenCV Library, O’Reilly, 2013.


| EEE-5305 | Biomedical Signal Analysis and Telemedicine | 3 Credits, 3 hours/week |
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**1. Classification of Signals.** Origin and dynamic characteristics of Biomedical signals. Difficulties of biomedical Data acquisition, . Digital Filters in medicine: Synchronizing Average Filter, Moving Average Filters, Optimal Filters, Adaptive Filters. ECG and Event detection Algorithms.

**2. Image Reconstruction:** Image reconstruction from projection data, X_Ray projection imaging Algorithms, CT image reconstruction Algorithms, MRI Imaging methods, PET and SPECT Imaging, Ultrasound Imaging, Infrared Imaging and Thermal Imaging. Pattern Classification and Diagnostic decision.

**3. Joint Time-Frequency Analysis,** Wavelet Transform, Harr wavelet, Harr Decomposition and Reconstruction Algorithms, Dube chies Wavelet. Medical Image Coding and Compression Techniques. Telemedicine: Online and Offline methods, System requirements, Advantages and Limitations, Bio, Clinical and Public health Informatics.

**Books:**

1. Medical Devices and Systems, Joseph D Bronzino
2. Medical Imaging Signals and systems, Jery l Prine & Jonathan Links, pearson , 2011.
3. A First course in Wavelet, Albert Boggess and F Narcowicc, Printice Hall.

| EEE-5306 | Video Processing and Coding Technology | 3 Credits, 3 hours/week |
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**1. Video Processing:** Representation of Digital Video, Spatio-temporal sampling, Motion Estimation algorithms, Motion compensation, Intra Frame Prediction, Faster algorithms for motion estimation, De-blocking, Video Filtering.

**2. Color Video**: Basics of color, color models in video (RGB, YUV, YCrCb).

**3. Video Compression:** Basic Video Compression Techniques, Introduction to video compression, video compression based on motion compensation, search for motion vectors, Video coding standards, MPEG-2, H.264.

**4. Video quality:** Subjective and objective evaluations.

**References:**
1. A. M. Tekalp, Digital Video Processing, Prentice-Hall, 1995
2. Yao Wang, Joern Ostermann, and Ya-Qin Zhang, Video Processing and Communications, Prentice Hall, 2002.
3. John W. Woods, Multidimensional Signal, Image, and Video Processing and Coding, John W. Woods, Second edition, 2011.
4. Zhou Wang, and Alan C. Bovik, Modern Image Quality Assessment, 2006.
5. V. Bhaskaran and K. Konstantinides, "Image and Video Compression Standards: Algorithms and Architectures", 2nd ed., Kluwer Academic Publishers, 1997.

| EEE-5307 | Random Signals and Processes | 3 Credits, 3 hours/week |
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Random variables, functions of a random variable, two random variables, sequences of random variables, parameter estimation, stochastic processes, power spectrum, minimum mean-square estimation, Markov chains, Poisson processes and martingales.

**References:**
1. A. Papoulis and S. Pillai, Probability, Random Variables and Stochastic Processes, McGraw-Hill, 4th edition
2. Grimmett & Stirzaker, Probability and random processes, Oxford
3. Stark & Woods, Probability, random processes, and estimation theory for engineers, Prentice Hall
4. Leon-Garcia, Probability, statistics, and random processes for electrical engineering, Addison-Wesley

| EEE-5308 | Information Theory and Coding | 3 Credits, 3 hours/week |
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**1. The statistical nature of communication,** Elements of information theory of discrete systems; information measures, memoryless and memory sources, the noiseless coding theorem, Methods of source coding, Information theory of continuous systems, Shannon's capacity theorem and its interpretation, Comparison of communication systems with the ideal. Applications of information theory in communications and signal processing.

**2. Elementary ideas of redundancy,** Fundamental problems in coding theory and practice. Distance measures, Bounds to the performance of codes, Important linear codes, Construction and properties of finite fields, Cyclic codes, BCH and Reed Solomon codes, Error correction for BCH and RS codes.

**References:**
1. Elements of Information Theory, T M Cover & J A Thomas, Wiley.

2. Information Theory, Inference, and Learning Algorithms, D MacKay, CUP, free at http://www.inference.phy.cam.ac.uk/mackay/itila/
3. Probability, Information and Coding Theory, P. S. Sathyanarayana, Dynaram Publication.
4. Error-Correcting Codes, W. Wesley Peterson and E. J. Weldon, The MIT Press, 2nd Edition.
5. Error-Control Coding for Data Networks, Irving S. Reed and Xuemin Chen, Springer, 1st edition.

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| **EEE-5309** | **Traffic Theory and Queuing Systems** | **3 Credits, 3 hours/week** |

Introduction to teletraffic analysis; Mathematical basis of traffic theory: Markov processes; Loss system analysis: route congestion in circuit-switched systems; models for overflow traffic; restricted availability; congestion in circuit switches; Delay-system analysis: introduction to queueing theory; congestion in message-switched systems and packet-switched systems; queueing network models; Analysis of random-access protocols; traffic characterisation of broadband services; admission and access control in broadband networks; routing in ATM networks. Performance/reliability (performability) models.

**References:**

1. Communication networks, Alberto Leon-Garcia & Indra Widjaja, McGraw-Hill, 2000
2. Data Networks, Bertsekas, D.P. and Gallger, R., Englewood Cliffs, NJ, 1992.
3. An introduction to Queueing theory & Stochastic Teletraffic Models, Moshe Zukerman
4. Queueing Systems, Volume 1: Theory, Leonard Kleinrock, John Wiley & Sons, NY.
5. Cooper, R. B. 1990. Introduction to queueing theory, CEE Press.
6. Girard, A. 1990. Routing in dimensioning in circuit-switched networks, Addision-Wesley.
7. Ross, K. W. 1995. Multiple loss model for broadband telecommunication networks, Springer-Verlag.
8. Schwartz, M. 1996. Broadband integrated networks. Prentice Hall.
9. Sahner R. A., Trivedi, K. S. and Puliafito A. 1995. Performance and reliability analysis of computer systems, Kluwer Academic Publ.

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| **EEE-5310** | **Network and Information Security** | **3 Credits, 3 hours/week** |

**1. Requirements for network security:** examples of types of network attack; passive and active communication channel and network management, traffic related protection by encryption and authentication, Digital signatures, Management controls, Importance of trusted parties in system management, Overhead, cost and other management aspects.

**2. Algorithms and standards:** private key systems and DES, Public key systems and RSA. Analysis of strength of protection, Weak keys, Attack by exhaustive search, Calculation of required key length, Types of analytic attack, Relationship with information and coding theory.

**3. Key management:** Diffie-Hellman key exchange, RSA key management, Public key certificates, Overall system management and management controls.

**4. Systems for network security:** VPN security, Wireless (including wireless LANs) security, LAN security, Internet security and the IPSec protocol.

**References:**

1. Network Security: Private communication in a public world, Kaufman, C, Perlman, R and Speciner, M., Prentice Hall, 2002.
2. Applied Cryptography, Schneier, B., John Wiley, 1996

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| **EEE-5311** | **Digital Speech Processing** | **3 Credits, 3 hours/week** |

The human vocal and auditory systems, Characteristics of speech signals: phonemes, prosody, IPA notation; Lossless tube model of speech production; Time and frequency domain representations of speech; window characteristics and time/frequency resolution tradeoffs; Properties of digital filters: mean log response, resonance gain and bandwidth relations, bandwidth expansion transformation, all-pass filter characteristics;

Autocorrelation and covariance linear prediction of speech; optimality criteria in time and frequency domains; alternate LPC parametrisation; Speech coding: PCM, ADPCM, CELP; Speech synthesis: language processing, prosody, diphone and formant synthesis; time domain pitch and speech modification; Speech recognition: hidden Markov models and associated recognition and training algorithms; Dynamic programming; Language modelling; Large vocabulary recognition; Acoustic preprocessing for speech recognition.

**References:**


1. Discrete-Time Processing of Speech Signals, JR Deller, Jr, JG Proakis & JHL Hansen, Macmillan, 1993.
2. Digital Processing of Speech Signals, LR Rabiner & RW Schafer, Prentice-Hall, 1978.
3. Statistical Methods for Speech Recognition, F Jelinek, MIT Press, 1998.


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| **EEE-5312** | **High Speed Computer Networking** | **3 Credits, 3 hours/week** |

**1. Driving forces for high speed networking,** High speed LANs, Fast Ethernet and Gigabit Ethernet, FDDI and DQDB, Frame relay architecture, Standards and protocols, Switched Multi Megabit Data Services, ATM standards & protocols, ATM LANs, Traffic and Congestion Control in ATM Networks, Optical Communication and SONET/SDH, Broadband access technologies, x-DSL, BISDN protocol and architecture, Broadband service aspects and access architecture, Broadband transmission network, Broadband access network technology, Cable TV networks, Hybrid Fiber Coaxial (HFC) network, Data

**2. Transmission Schemes:** DOCSIS, Congestion Control and QoS in Data Networks and Internets, Advanced network architectures, Overlay model, MPLS, RSVP, Differentiated services, VOIP, H.323, Session initiation protocol, PSTN vs. VOIP, VSAT networks.

**3. IEEE 802.11 (WiFi)& IEEE 802.16 (WiMAX):** Network structure, Protocol stack, PHY layer, MAC layer, QoS, mobility, OFDMA, SOFDMA, Subchannelization, Adaptive modulation and coding, Frame structure, Spectral efficiency, Network capacity, LTE, Beyond 4G.

**4. IEEE 802.15 (WPAN / Bluetooth):** Architecture, Piconets, Scatternet, Bluetooth layers, Radio layer, Baseband layer, frame format, L2CAP, QoS, High Rate WPAN, Low Rate WPAN, mesh networking, Body Area Networks, visible light communication, Wireless Next Generation.

**IEEE 802.20 (MBWA):** Technical specification and advantages, Network structure, Co-existence, comparison with other wireless systems, Spectral efficiency, and Network capacity.

**References:**


1. Data Communications & Networking, Behrouz A. Forouzan, TATA McGraw-Hill, 4$^{th}$ edition.
2. Communication networks, Alberto Leon-Garcia & Indra Widjaja, McGraw-Hill, 2000.
3. Voice over IP Technologies, Mark A. Miller, Wiley-dreamtech, 2005.
4. Data and Computer Communications, William Stallings, Prentice-Hall, 8$^{th}$ edition.
5. Computer Networks & Internets with Internet Applications, Douglas E. Comer, Pearson Education, 4$^{th}$ edition.
6. High-Speed Networks and Internets: Performance and Quality of Service, William Stallings, Prentice-Hall, 2$^{nd}$ Edition.


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| **EEE-5313** | **Advanced Data and Mobile Communication** | **3 Credits, 3 hours/week** |

**1. Discrete Data Transmission**: Modulation, demodulation, discrete data detectors, ML and MAP detectors, AWGN noise and bit error rate as a function of SNR, Union bound approximation, PSK, PAM and QAM systems

**2. Transmission through ISI Channels:** Inter Symbol Interference, ISI model, Nyquist criterion, Raised cosine pulse, Zero Forcing Equaliser (ZFE), MMSE Linear Equaliser, Decision Feedback equalizer, Error propagation, precoders: Tomlinson, Larcia.

**3. Multi Channel Modulation:** Basic multi tone, gap analysis, water filling optimization, Rate adaptive, Margin adaptive water filling algorithm, Discrete loading: Chow’s algorithm, Levin Campello algorithm, Dynamic loading, channel partitioning, modal modulation, Discrete Multi-tone

**4. Coding and Sequences, Sequential Detection:** Convolution codes, Maximum Likelihood (ML) algorithm for sequential detection, Viterbi algorithm, MAP algorithm for sequential detection, Iterative decoding, Turbo codes, Low Density Parity Check codes, Partial response Decision Feedback Turbo equalization

**5. Mobile radio channels:** Path loss, slow-fading, fast-fading, Doppler spread and coherence time, delay spread and coherence bandwidth, flat fading and frequency selective fading, The power budget design of mobile radio channels

**6. System Capacity:** Average capacity, Shannon capacity /water filling approach, Rate Adaptive loading and power allocation, Capacity for narrow and wideband systems

**7. Advanced wireless transmission and systems:** CDMA technology, Advanced orthogonal multicarrier modems, Spectral efficiency of wireless systems, Comparison of existing wireless systems and standards, Future narrow- and wide-band wireless multimedia systems, UMTS, Wideband system 1 (2G/GSM _2.5G): Air interface, 2.5 G transition from 2G to 3G. Backbone networks, Wideband system 2: Back bone networks and 3G air interface, DSSS for 3G, Link optimization, Iterative Water Filling for power allocation

**References:**


1. Signal Processing and Detection, John Cioffi.
2. Communication Systems Engineering, Proakis and Salehi, Second edition.
3. Modulation and Coding for Wireless Communications, Burr A, Prentice Hall, 2001.
4. Digital Communications Fundamentals and Applications, Sklar B, Prentice Hall, 2001.
5. Digital Communications, Haykin S, Wiley, , 2001.
6. Digital Communications, Bateman A, Addison-Wesley, 1999.
7. Digital Communications, Proakis JG, McGraw Hill, , 2001.
8. Digital Communications, Glover IA and Grant PM, Prentice Hall, 1998.
9. Wireless Communications, Principles and Practice, Rappaport TS, Prentice Hall, 2002.
10. An Introduction to GSM, Redl SM, Weber MK and Oliphant MW, Artech House, 1995.
11. Principles and Applications of GSM, Garg VK and Wilkes JE, Prentice Hall, 1999.
12. Introduction to Digital Communication, Zieman, RE and Peterson, RL, Prentice Hall, 2001.
13. Single- and Multi-Carrier Quadrature Amplitude Modulation: Principles and Applications for Personal Communications, WLANs and Broadcasting, L Hanzo, W Webb and T Keller, Wiley, 2000.
14. Mobile Radio Communications, R Steele and L Hanzo (Ed), IEEE Press-John Wiley, 2nd edition, 1999.
15. Wireless Communications, Andre Goldsmith.
16. Third Generation Systems and Intelligent Networking, J. S. Blog and L. Hanzo.
17. Wireless Communication Systems, X. Wang and H.V. Poor.
18. Fundamentals of Wireless Communication, David Tse and Pramod Viswanath.
19. WCDMA for UMTS, Harri Holma and Antti Toskala.
20. Third Generation Systems and Intelligent Networking, J. S. Blog and L. Hanzo.
21. WCDMA Mobile Communication Systems, Keija Tachikawa.
22. GSM Switching, Services and Protocols, J. Eberspacher and H. Vogel, Wiley, 1999.
23. GSM - Evolution towards 3rd Generation Systems, Z. Zvonar, P. Jung and K. Kammerlander, Kluwer, 1999.
24. The GSM System for Mobile Communications, M. Mouly and M. Pautet, Cell & Sys, 1992.


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| **EEE-5314** | **Advanced Communication Theory** | **3 Credits, 3 hours/week** |

**1. Introductory concepts:** Modelling of information sources, Communication channels and sinks, Definitions of priori and posterior probabilities in relation to the model of a communication channel, MAP criterion, likelihood functions and likelihood ratio, An initial study on the performance of a digital communication system and expansion to a spread spectrum system.

**2. Optimum detection theory:** Detection criteria, Receiver operating characteristics (ROC), Detection of known signals in the presence of white noise and the concept of an optimum receiver, Matched filter receivers and their mathematical analysis, Extension to non-white noise, Orthogonal signals and the approximation theorem, M-ary signals and signal constellation, Basic concepts and analysis of orthogonal and biorthogonal M-ary communication systems, 64-ary Walsh-Hadamard signal set.

**3. PN-sequences:** Galois field GF(2) basic theory, Shift registers, Basic properties of m-sequences, Statistical properties of m-sequences, Gold sequences.

**4. PN-signals:** Modelling, Cross/Auto correlation functions and Power spectral density, Partial correlation properties.

**5. Spread spectrum systems (SSS):** Basic concepts and parameters, Classification and modelling of jammers, Modelling of BPSK and QPSK direct sequence SSS in a jamming environment, Estimation of SNIR and bit-error-probability, Direct sequence SSS on the (SNR/pe, EUE, BUE) parameter plane, Frequency hopping SSS.

**6. Principles of CDMA system:** Investigation of important system components with special attention given to RAKE receiver, Modelling and analysis with emphasis given on capacity issues, An overview of the TIA/ISA IS-95 CDMA standards, Wideband CDMA (3G).

**7. Space-time communications:** Definitions, notation, spaces and projection operators, Modelling an array received signal-vector and the concept of the array manifold, Multidimensional correlators, Estimation of signal parameters including directions of arrival, powers, cross-correlations, etc., Array pattern and beamformers, Vector-channel effects (including multipaths, angular spread, Doppler spread and fading), Outage probability, Integrated array CDMA systems, Single-user and multi-user array CDMA receivers.

**References:**
1. Introduction to Spread Spectrum Communications, R.L.Peterson, R.E.Ziemer and D.E. Borth, Prentice Hall, 1995.
2. Fundamentals of Wireless Communication, D. Tse and P. Viswanath, Cambridge University Press, 2005.
3. Differential Geometry in Array Processing, A. Manikas, Imperial College Press, 2004
4. Digital Communications, I. A. Glover & P.M. Grant, Pearson and Prentice hall, 2004.
5. Communication Systems, S. Haykin, J. Wiley & Sons, 4th edition, 2001.
6. Introduction to Digital Communications, R.E. Ziemer & R.L. Peterson, MacMillan, 2nd edition, 2001.

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| **EEE-5315** | **MIMO Wireless Communications** | **3 Credits, 3 hours/week** |

**1. Channel fading and diversity, Channel modeling and propagation:** fading channels, multi-dimensional propagation, analytical MIMO channel representations, physical MIMO channel models. MIMO Capacity: ergodic capacity of iid, correlated and rician fading channels, Outage Capacity and Diversity-Multiplexing Trade-Off of iid, correlated and rician fading channels.

**2. Space-Time Coding in iid channels:** Error Probability and information theory based design for fast and slow fading channels, Space-Time Block Coding, Spatial Multiplexing, MIMO receiver: ML, SIC, linear receivers. Space-time coding for general channels: error probability for fast and slow general fading channels; Space-time coding with partial transmit channel knowledge: channel statistics based precoding, quantized precoding. Space-time coding for frequency selective channels: ergodic capacity and outage capacity, diversity multiplexing tradeoff, code design for single-carrier and multi-carrier. Multi-User MIMO: Capacity of Multi-User MIMO channels (Broadcast and Multiple-access channels), Multi-User Diversity and Scheduling, Multi-User MIMO Linear Precoding, Multi-User MIMO Non-Linear Precoding, Multi-User MIMO Precoding with Partial Transmit Channel Knowledge. Introduction to multi-cell design and interference channel, MIMO in 4G (LTE, LTE-Advanced and WiMAX) and beyond.

**References:**
B. Clerckx and C. Oestges, “MIMO Wireless Networks: Channels, Techniques and Standards for Multi-Antenna, Multi-User and Multi-Cell Systems”, Academic Press (Elsevier), Oxford, UK, Jan 2013.

## *Group: Power Systems*

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|---|---|---|
| **EEE-5401** | **Power Plant Engineering** | **3 Credits, 3 hours/week** |

**1. Generation of Electricity and Sources of Energy:** Major sources of energy, Salient features, selection of site, basic schemes and constituents of Steam, Hydro, Nuclear, Diesel and Gas Turbine Power Stations. Cogeneration, Hydrothermal Energy coordination.

**2. Steam Power Plants:** Thermodynamic cycles and use of high steam pressure and temperature. Super heating of steam. Reheat cycle. Regenerative cycle. Binary vapour cycle. Coal Classification, use of high ash coal, Coal supply, storage and handling, Ash handling and dust collectors.

**3. Steam Generators:** Fire tube and water tube boilers. Modern boilers. Economiser and air preheater, condenser, supply of cooling water to condenser, cooling towers.

**4. Steam Primovers:** Impulse and reaction types. Heat balance and efficiency.

**5. Station Auxiliaries:** Types of auxiliaries, power supply scheme for auxiliaries. Modern development in steam power plants.

**6. Hydro Electric Plants:** Selection of site, classification and basic schemes. Types of turbines, capacity calculation. Pump storage projects.

**7. Nuclear Power Plant:** Types of fuels. Classification of reactors, methods of cooling; moderators, methods of control, safety measures,

**8. Basic Schemes of Nuclear Power Stations:** Boiling water reactor, pressurized heavy water reactor, fast breeder reactor, Cost of Nuclear Energy. Nuclear Power Stations.

**9. Gas Turbine Power Plants:** Operation of gas turbine power plant, open cycle plant, closed cycle plant, Combined gas turbine and steam turbine cycle.

**10. Comparative Study of Thermal, Hydro, and Nuclear Power Stations:** Economic comparison of power stations, Inter connections. Base and peak load power stations. Impact of thermal, hydro and nuclear stations on environment.

**11. New Energy Sources:** Principle of MHD power generation, open cycle MHD system and closed cycle MHD system. Wind power generation.

**12. Solar Power Generation:** Solar power plant, photo voltaic cell, photo voltaic power generation. Tidal power generation. Geothermal

**Reference Books:**

1. Electric Power Generation, Transmission and Distribution by Leonjard L. Grigsby
2. Power Station Engineering and Economy by Bernhardt G.A. Skrotzki, Tata McGraw Hill
3. Power Plant Technology by EI- Wakil M.M, McGraw-Hill 1984.
4. A course in Power Plant Engineering by Arora S.C and Domkundwar S, Dhanpatrai, 2001.
5. Power plant Engineering by Nag P.K, Tata McGraw-Hill, 1998.

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| **EEE-5402** | **Power System Analysis** | **3 Credits, 3 hours/week** |

**1. Power network matrix operation:** Nodal method for formation of admittance matrix. Modification of Y-bus due to inclusion of regulating transformer between two buses. Formation of complete Y-bus for a general network.

**2. Complex Power Flow:** Analytical formulation of complex power flow solution. Gauss-Seidel method of power flow. N-R method in power flow studies. Algorithm for solving the power flow problem using N-R method in rectangular and polar form. Fast de-coupled load flow method.
ILL-conditioned system. Solution of load flow for ill-conditioned system.

**3. Fault Studies:** Symmetrical faults, Unsymmetrical faults, concept of sequence components, Koga components. Unsymmetrical fault studies using sequence components and Koga components. Open circuit fault analysis.

**4. Transient Stability:** An elementary view of transient stability, stability analysis in numerical integration methods (Euler and R-K methods). Small signal stability of a signal machine connected to infinite bus. Effect of synchronous machine field circuit on stability. Small Signal Stability with Multi-machine system.

**5. Voltage Stability and Reactive Power Control:** Definition and classification of voltage stability, Mechanism of voltage collapse, Analytical concept of voltage stability for a two bus system, Reactive power and voltage collapse, Reactive power requiring of an uncompensated line, Expression for critical receiving end voltage and critical power angle at voltage stability limit for a two bus power system, Reactive compensation methods for heavily loaded and voltage stressed power system to enhance voltage stability, Determination of voltage stability using sensitivity indicator, A voltage security indicator combining Fast Decoupled Load Flow and Newton Raphson Load flow methods, Determination of voltage stability by Q-V model analysis, Determination of voltage stability using optimal power flow technique.

**Reference Books:**

1. Power system Analysis by Hadi Saadat: Tata McGraw-Hill Publishing Company Limited.
2. Power system Analysis by Charles A. Gross: John Wiley & Sons.
3. Power system Analysis by John J. Grainger & William D. Stevenson, JR: Tata McGraw-Hill Edition.
4. Power system Analysis Operation and control by Abhijit Chakrabarti & Sunita Halder: Prentice-Hall of India, New Delhi-110001.
5. Computer techniques in Power System Analysis by M.A.Pai, TMH, S
6. Elements of Power System Analysis by William D. Stevenson, Jr, McGraw Hill

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| **EEE-5403** | **Power System Operation and Control** | **3 Credits, 3 hours/week** |

**1. Optimal Generation Scheduling:** Thermal System Dispatching with Network Losses Considered, The Lambda-Iteration Method, Gradient Methods of Economic Dispatch - Gradient Search, Newton's Method, Economic Dispatch with Piecewise Linear Cost Functions, Economic Dispatch Using Dynamic Programming, Base Point and Participation Factors, Economic Dispatch Versus Unit Commitment, Coordination Equations, Incremental Losses, and Penalty Factors, The ***B*** Matrix Loss Formula Exact Methods of Calculating Penalty Factors, Reference Bus Versus Load Center Penalty Factors Reference-Bus Penalty Factors Direct from the AC Power Flow

**2. Optimal Power flow:** Optimal VAR control problem, controllable variables- Transformer taps, Generator voltages, Switchable shunt capacitors and Reactors, Objective functions, network performance constraints, constraints on state variables, Mathematical formulation, Solution of the Optimal Power Flow- The Gradient Method, Newton's Method, Linear Sensitivity Analysis, Linear Programming Methods, Sensitivity Coefficients of an AC Network Model Linear Programming Method with Only Real Power Variables, Linear Programming with AC Power Flow Variables and Detailed Cost Functions, Security-Constrained Optimal Power Flow, Interior Point Algorithm, Bus Incremental Costs

**3. Load Frequency Control:** control area concept, Block diagram and LFC of an isolated power system, Governor droop characteristic, AGC, primary and secondary frequency control, LFC of inter-connected power systems, Modes of tie line operation-flat frequency, flat tie line, tie line with frequency bias, Area control error, State space representation of two area system

**4. State Estimation:** Types of estimators–static, dynamic, tracking estimators. Least Squares and Weighted Least squares estimation, formulation, solution techniques, Bad data identification and detection.

**5. Security Analysis:** Normal, Alert, emergency, Restoration states in a power system. Security analysis, Security assessment, Security monitoring and Security controls Credible and incredible contingencies, Contingency identification and Contingency ranking, Security Calculation procedures

**6. Deregulation:** What is deregulation? Background to deregulation and current situation, Benefits of a competitive electricity market,

***Reference Books:***

1. Power Generation, Operation and Control by Allen. J. Wood and Bruce F. Wollenberg, John Wiley & Sons, Inc., 2003.
2. Power System Analysis: Operation and Control by Chakrabarti & Halder, Prentice Hall of India, 2004 Edition.

| EEE-5404 | Power Electronics | 3 Credits, 3 hours/week |
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**1. Solid State Power Semiconducting Devices:** Review of the Thyristors, TRIAC, GTO, transistor, MOSFET and other modern power devices (IGBT, SIT, SITCH, MCT), characteristics, ratings, commutation methods, protection and requirement of firing circuits.

**2. Phase Controlled Converters:** Single and three phase controlled converters, power factor improvement techniques. Dual Converter mode of operation, Firing Circuits.

**3. Choppers:** Review of choppers, commutation circuits, firing circuits. Introduction to multiquardant and multi phase choppers.

**4. Inverters and Cycloconverters (Frequency Conversion):** Line commutated, voltage source, and current source inverters; Commutation techniques, Voltage control and harmonic reduction techniques. PWM rectifiers and inverters. Single phase and three phases cycloconverters. Power Electronics Controller for Wind Energy Electric Conversion Systems, Photo Voltaic Arrays, energy Saving in AC and DC Drives. Power Factor Improvements, Extinction Angle, Symmetrical Angle. PWM Control and Sinusoidal PWM Control power techniques.

**Reference Books:**

1. Power Electronics Circuits, Devices and Applications by Muhammad H. Rashid
2. Power Electronics Design Handbook by Nihal Kularatna

| EEE-5405 | Power System Stability | 3 Credits, 3 hours/week |
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**1. Synchronous Machines:** Modelling of cylindrical rotor synchronous machine, flux linkage equations, voltage equations and equivalent circuit, real and reactive power control. Modelling of salient pole synchronous machine (Two axis model), flux linkage equations, Park’s transformation, current and voltage equations. Transient and subransient effects, reactances and time constants of synchronous machines. Equivalent circuits, vector diagrams, power angle equations and characteristics under steady state and transient conditions.

**2. Steady State and Dynamic Stabilities:** Development of swing equation, linearisation of swing equation. Steady state stability of single machine connected to an infinite bus system and two machine systems. Coherent and non-coherent machines. Swing equation including damping effect. Introduction to dynamic stability of power system. Introduction to classical model of multi machine system.

**3. Transient Stability:** Equal area criterion and its application to transient stability studies under common disturbances including short circuits. Critical clearing angle and critical clearing time. Numerical solution of swing equation by step-by-step method.
**(i) Multi machine Transient Stability:** Numerical methods for solution of differential equations: Modified Euler Method, Runge – Kutta fourth order method. Multi machine transient stability studies using modified Euler method and Range – Kutta fourth order method.
**(ii)** Factors affecting steady state and transient stabilities. Methods of improving steady state, dynamic and transient stabilities, series capacitor compensation of lines, excitation control, power stabilizing signals, High speed circuit breaker, and auto – recolsing circuit’s breaker, single pole and selective pole operation, by pass valving and dynamic braking.

**Reference Books:**

1. Kundur, P. Power System Stability and Control, McGraw-Hill International Editions, 1994. 2. Anderson,

P.M. and Fouad, A.A., Power System Control and Stability, Galgotia Publications, New Delhi, 1994.
3. Van Cutsem, T. and Vournas, C. Voltage Stability of Electric Power Systems, Kluwer Academic Publishers, 1998.

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| **EEE-5406** | **Electrical Distribution Systems** | **3 Credits, 3 hours/week** |

**1. Basic schemes distribution systems,** Radial network, Primary loop network, Primary Selective, Secondary Selective, Spot network, Grid network, Industrial and commercial distribution systems

**2. Development of MDEPL model,** calculation of total technical losses, commercial losses, techniques of minimization of losses in distribution systems

**3. Grounding system,** design of earth electrode systems, temporary grounding, solidly earthed, resistive earthed systems, Comparison of over head lines and underground cable system, short circuit and loss calculations

**4. Distribution system reliability,** probability concepts, Markov model, reliability measurement, Power quality, Distribution system expansion planning, design concepts, optimal location of substation, design of radial lines, load forecasting

**5. Voltage control,** Application of shunt capacitance, static VAR systems, loss reduction and voltage improvement, Harmonics in the system

**6. System protection:** fuses and section analyzers, over current, under voltage, under frequency protection, coordination of protective devices

**Reference Books:**

1. Electrical Power Distribution System by Pabla, A.S, Tata McGraw Hill.
2. Electrical Power Distribution System Engineering by TMH Tuvar Goner
3. Power System Control, Sterling, M.I.H. Peter Peergisus

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| **EEE-5407** | **AI Applications to Power Systems** | **3 Credits, 3 hours/week** |

**1. Introduction to AI:** Definition, Applications, Components of an AI program; production system. Problem Characteristics. Overview of searching techniques.

**2. Knowledge Representation:** Knowledge representation issues; and overview. Representing knowledge using rules; procedural versus declarative knowledge. Logic programming, forward versus backward reasoning, matching. Control knowledge.

**3. Statistical Reasoning:** Probability and Daye's theorem. Certainty factor and rule based systems. Baysian Networks, Dampster Shafer theorem. Semantic nets and frames, Scripts. Examples of knowledge based systems.

**4. Pattern Recognition:** Introduction, automatic pattern recognition scheme. Design Concepts, Methodologies, Concepts of Classifier, concept of feature selection. Feature selection based on means and covariances. Statistical classifier design algorithms; incrementcorrection and LMSE algorithms. Applications. Artificial Neural Networks: Biological Neuron, Neural Net, use of neural 'nets, applications, Perception, idea of single layer and multilayer neural nets, backpropagation, Hopfield nets, supervised and unsupervised learning.

**5. Expert Systems:** Introduction. Study of some popular expert systems, Expert System building tools and Shells, Design of Expert Systems.

**Reference Books:** Artificial intelligence Techniques in Power Systems - Editors: Kevin Warwick ; Arthur Ekwue ; Raj Aggarwal

| EEE-5408 | **Advanced Power System Protection** | **3 Credits, 3 hours/week** |
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**1. Relaying:** Review of Relay characteristics, Classification of Relays, characteristics and operating equation. Protective Current & Potential Transformers: Types, Rating, Accuracy, burden, Polarity, connections and Transient Response. Static Relays: Introduction, advantages of static relays over electromagnetic relays. Limitation of static relays, Reliability and Security of static realys, Recent Developments of static relays.

**2. Comparators and Level Detectors:** Static Relay Functional circuits, Amplitude and Phase comparators, level detectors. Static Over current Relays: Introduction to static overcurrent relays, single actuating and Double actuating quantity relays, Basic principle of static overcurrent relays, time characteristics, timing circuit, Directional overcurrent relay, static time lag overcurrent relays. Static Directional relays. Static Differential Protection to Power Transformers, Static Busbar protection based on Directional comparison. Static Distance Relays and Distance Protection of EHV Lines. Influence of power swings on Distance protection. Directional wave Relays for fault protection and protection of overhead lines. Relay setting coordination, transient over voltages in static relay, protection of static relay circuit. Digital Relays, Microprocessor based protective relays. Switchgear: Types of circuit breakers and their constructional features, operating mechanism Application of Circuit breakers, speed of circuit breakers, Autreclosing, selection of circuit breakers, Rating of circuit breakers, Testing of circuit breakers, SF6 Insulated Metal clad Switchgear (CIS), Advantages, Demerits, Design aspects, Busbar modules, SF6 Insulated EHV Transmission Cables (GIC).

**Reference Books:**

1. Fundamentals of Power System Protection by Y.G. Paithankar and S.R Bhide, Prentice-Hall of India, 2003.

2. Power System Stability and Control by P.Kundur, McGraw-Hill, 1993.

3. Power System Protection and Switchgear by Badri Ram and D.N. Vishwakarma, Tata McGraw-Hill Publishing Company, 2002

4. Switchgear Protection and Power Systems by Sunil S. Rao, Khanna Publshers, Delhi 110006

| EEE-5409 | **Power System Planning and Reliability** | **3 Credits, 3 hours/week** |
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**1. Load Forecasting:** Load Forecasting Categories-Long term, Medium term, short term, very short term Applications of Load Forecasting, Factors Affecting Load Patterns Medium and long term load forecasting methods- end use models, econometric models, statistical model based learning. Short Term Load Forecasting (STLF): Applications of Load Forecasting, methods- similar day approach, regression methods, time series, ANN, Expert systems, Fuzzy logic based method, support vector machines ANN architecture for STLF, Seasonal ANN, Adaptive Weight, Multiple-Day Forecast, STLF Using MATLAB'S ANN Toolbox, Training and Test Data, Stopping Criteria for Training Process, sensitivity analysis

**2. Power System Reliability:** Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems.

**3. Basic Tools and Techniques**- random processes methods & Markov models, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.

**4. Reliability of Generation Systems-** capacity outage calculations, reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion,

**5. Reliability Assessment for Elements of Transmission and Transformation Systems-** reliability indices of substations based on the overload capability of the transformers, evaluation and analysis of substation configurations, Reliability analysis of protection systems for high voltage transmission lines,.

**Reference Books:**

1. Markey Operations in Electric Power Systems Forecasting, Scheduling, and Risk Management by Shahidehpour M, Yamin H, Li z, John Wlley & sons
2. Reliability Evaluation of Power Systems by Billinton R, Allan R (1996) Plenum Press New York
3. Computational Methods in Power system Reliability by D. Elmakias, Springer-Verlag

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| **EEE-5410** | **Power System Instrumentation** | **3 Credits, 3 hours/week** |

**1. Transducer Instrumentation:** Primary sensors, voltage and current generating analogue Transducers, variable parameter analogue Transducers, Frequency generating and Digital Transducers, transducer selection factors.

**2. Digital Instrumentation:** Introduction, Basic measurement system. Digital voltage measurement, Frequency measurement, Time measurement, Digital phasemeter, digital multimeter. Digital displays. Telemetry System: Introduction to Information Transmission. Basic ideas.

**3. Point to Point Telemetering:** Basic principles, pneumatic and electrical system, voltage and current telemetry, impulse codal telemetry.

**4. Radio Telemetering:** Basic principles of AMFM systems. Instrumentation Associated with **Power Plant:** Centralized Control and Measurement in Thermal, Hydro and Nuclear Power Plants. Power Line Carrier Principles.

**References:**

1. Electrical Instrumentation and Measuring Techniques by Cooper Helfrick, Prentice Hall India, 1986
2. Instrumentation, Measurement, and Analysis by D. C. Nakra and K. K. Chowdhry, Tata McGraw Hill Publishing Co., 1984.
3. Electrical & Electronic Measurements and Instrumentation by A.K. Sawhney, Dhanpat Rai and Sons, 2003.
4. Modern Power Station Practice, Volume F, British Electricity International Ltd., Central Electricity Generating Board, Pergamon Press, Oxford, 1991
5. “Control & Instrumentation”, NPTI Manuals Volumes I,II,III.

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| **EEE-5411** | **Economics and planning of Energy Systems** | **3 Credits, 3 hours/week** |

System Economics: Basic concepts, National accounting framework. Criteria for economic growth. Model types and philosophy. Production functions. Inputoutput economics, macro-economic growth models. "Econometric" models, policy options and budgetary Implication, some illustrations of economic research for identifying demand functions, supply functions, cost functions, production functions, utility functions and Engel curves. Dynamic models of the economy and "Simple" theory of business fluctuations. Multiple linear and nonlinear regression analysis, energy per unit monetary value of consumer needs and services. Energy efficiency, Costbenefit risk analysis. Environmental repercussions and the economic structure. Conflict between energy consumption and pollution. Systems Design and quantitative economic policy with particular references to energy. Econometric in the context of multiple objectives, conflicting goals and decisions under uncertainty.

**Reference Books:** Energy Economics – Subhes C. Bhattacharya

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| **EEE-5412** | **Power System Transients and High Voltage Engineering** | **3 Credits, 3 hours/week** |

Wave terminology, development of wave equations, terminal problems, lattice diagrams. Origin and nature of power system surges, wave shapes, attenuation, effect of shielding by ground wires and masts, tower footingresistance. Traveling waves, multivelocity waves, methods of measuring tower footing resistance, voltages across insulator strings. Dynamic over voltages during surges and system faults, system recovery voltage characteristics. Methods of neutral grounding and their effect on system behaviour. Insulation coordination, requirement in surge protection of lines and equipment. Impulse generator development. Impulse testing technique. Power frequency h.v. transformers, cascade connection. H.V.D.C. generators, tests with power frequency and d.c. voltages. Large current generating and measurement techniques. Partial discharge testing. High voltage and high current testing of power equipment. Field investigations. Magnetic links their calibration and mounting, klydenographs, potential dividers and cathodes ray oscillorgraph.

**Reference Books:**

1. High Voltage Engineering by E. Kuffel, W. S. Zaengl and J. Kuffel
2. Electrical Transients in PowerSystems by Allan Greenwood, 2nd Edition, Wiley Interscience, 1991.
3. Extra High Voltage AC Transmission Engineering by Begamudre, R.D., 3rd Edition,

   NewAge International, 2009.
4. High Voltage Engineering by Naidu, M.S. and Kamaraju, V., 2nd Edition, Tata McGraw Hill, 2000.

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| **EEE-5413** | **Smart Grid Design and Analysis** | **3 Credits, 3 hours/week** |

**1. Smart Grid Architectural Designs:** Introduction – Comparison of Power grid with Smart grid – power system enhancement – communication and standards - General View of the Smart Grid Market Drivers - Stakeholder Roles and Function - Measures - Representative Architecture - Functions of Smart Grid Components-Wholesale energy market in smart grid-smart vehicles in smart grid.

**2. Smart Grid Communications And Easurement Technology:** Communication and Measurement - Monitoring, Phasor Measurement Unit (PMU), Smart Meters, Wide area monitoring systems (WAMS)-Advanced metering infrastructure- GIS and Google Mapping Tools.

**3. Performance Analysis Tools For Smart Grid Design:** Introduction to Load Flow Studies - Challenges to Load Flow in Smart Grid and Weaknesses of the Present Load Flow Methods - Load Flow State of the Art: Classical, Extended Formulations, and Algorithms –Load flow for smart grid design-Contingencies studies for smart grid.

**4. Stability Analysis Tools For Smart Grid:** Voltage Stability Analysis Tools-Voltage Stability Assessment Techniques-Voltage Stability Indexing-Application and Implementation Plan of Voltage Stability in smart grid-Angle stability assessment in smart grid-Approach of smart grid to State Estimation-Energy management in smart grid.

**5. Renewable Energy And Storage:** Renewable Energy Resources-Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues-Electric Vehicles and Plug-in Hybrids-PHEV Technology-Environmental Implications-Storage Technologies-Grid integration issues of renewable energy sources.

**Reference Books:**

1. Smart Grid: Fundamentals of design and analysis by James Momoh, John Wiley & sons Inc, IEEE press 2012.

2. Smart Grid: Technology and Applications by Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, John Wiley & sons inc, 2012.

3. Smart Grid: Integrating Renewable, Distributed & Efficient Energy by Fereidoon P. Sioshansi, Academic Press, 2012.

4. The Smart Grid: Enabling Energy Efficiency And Demand Response by Clark W.Gellings, Fairmont Press Inc, 2009.

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| **EEE-5414** | **Power Conversion Techniques** | **3 Credits, 3 hours/week** |

DC-DC converters-Buck converter, boost converter, buck-boost converter, averaged circuit modeling, input-output equations, ripple calculations, filter design DC-AC inverters -Single phase VSI, Three phase VSI, Single phase CSI, Three phase CSI, voltage control and harmonic reduction in inverters-standard PWM techniques. AC-DC converters- Uncontrolled (Diode rectifier), single and three phase fully controlled ( SCR-line commutated) and semicontrolled converters, continuous current conduction, discontinuous current conduction, Reactive compensation, Harmonic compensation techniques. AC-AC converters-single phase and three phase circuits employing Phase angle control, on-off control. AC choppers. Loss calculations and thermal management: Device models for loss calculations, ratings, safe operating areas, data sheets, forward conduction loss, switching losses, heat sink design, snubber design drive and protection circuits, commutation circuits, Soft switching.

**Reference Books:**

1. Power Electronics: converters, Application and design by Ned Mohan, Undeland and Robbin, John Wiley and sons.Inc, Newyork, 3rd edition,2002.

2. Power Electronics Circuits, Devices and Applications by Rashid M.H., Prentice Hall India, New Delhi, 3rd edition ,2004.

3. Understanding FACTS by N.G.Hingorani and L.G.Gyugyi, IEEE press, New York, 2000 ISBN –078033 4588., 1998.

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| **EEE-5415** | **Power System Dynamics** | **3 Credits, 3 hours/week** |

**1. Introduction**: Basic concepts and classification of power system stability, Synchronous Machine theory and modeling: Mathematical description of synchronous machine, dq0 transformation, Per unit representation, Equivalent circuit for direct and quadrature axis. Steady state analysis, Electrical transient performance characteristics, Magnetic saturation, Representation of saturation in stability studies

**2. Excitation Systems**: Elements and requirements of excitation systems, Types of excitation systems, Dynamic performance measures, Control and protective functions, Mathematical modeling of separately excited and self excited DC excitation systems.

**3. Power system loads and Prime mover models:** Basic load modeling concepts, Issues in load modeling, Mathematical modeling of induction motor, Acquisition of load-model parameters, Configurations of steam, hydro turbines and speed governing systems.

**4. Small Signal Stability**: Concepts of stability in dynamic systems, Synchronizing power coefficient, state space representation, linearization, Eigen properties, SMIB system small signal stability analysis, Effect of excitation, PSS and damper windings.

**5. Voltage Stability**: Voltage collapse, Voltage stability analysis, Prevention of voltage collapse, Midterm and long term stability.

**6. Transient Stability Analysis:** Introduction, Mechanics of rotatory motion, Swing equation, Power angle equation for non salient pole machine and for a salient pole machine, Equal area criterion-Applications, Transient stability enhancement techniques, multi-machine transient stability analysis.

**7. Numerical solutions for swing equation:** Modified Eulers method, Runge Kutta method, Step by Step method, Milnes prediction method.

**References:**


1 Power System Stability and Control by Prabha Kundur., McGraw-Hill Publishing Company, NY, 2006.

2 Power System Dynamics by Padiyar K.R., 2nd edition, BS Publishers, 2008.

3 Computer Techniques and Models in Power Systems by K. Uma Rao, 1st edition, I. K. International, 2007.

4 Dynamics and Control of Large Electric Power Systems by Marija Ilic, John Zaborszky, IEEE Press and John Wiley & Sons, Inc, 2000.

5 Power System Control and Stability by Paul M. Anderson and A. A. Fouad, 2nd edition, IEEE Press and John Wiley & Sons, Inc, 2003.

6 Power System Dynamics, Stability and Control by Padiyar K.R., 2nd edition, BS publications, 2006.


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| **EEE-5416** | **Renewable Power Generation Sources** | **3 Credits, 3 hours/week** |

Basic characteristics of sunlight – solar energy resource – photovoltaic cell-characteristics – equivalent circuit – photo voltaic for battery charging.
Wind source – wind statistics - energy in the wind – aerodynamics - rotor types – forces developed by blades- Aerodynamic models – braking systems – tower - control and monitoring system – power performance Wind driven induction generators -power circle diagram -steady state performance – modeling-integration issues – impact on central generation- transmission and distribution systems – wind farm electrical design. Wind-diesel systems-fuel savings-permanent magnet alternators – modeling – steady state equivalent circuit-self-excited induction generators – integrated wind-solar systems.
Micro-hydro electric systems – power potential – scheme layout – generation efficiency and turbine part flowisolated and parallel operation of generators – geothermal-tidal and OTEC systems.

**References:**


1. Wind energy Technology by John F.Walker & Jenkins. N, John Wiley and Sons
2. Physics, Technology and use of Photovoltaics by Van Overstraeton and Mertens R.P
3. Wind Energy Conversion Systems by Freries LL, Prentice Hall \


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| **EEE-5417** | **Communication for Power System Operation and Management** | **3 Credits, 3 hours/week** |

*To be briefed in class by course instructor.*