First Year

Course Title	Course Code	Structure (I-P-C)		
Differential and Integral Calculus	**DS101**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Apply limit concept to determine a given function of one variable is continuous/differentiable at a given point.
CO2	Find approximation of nonlinear function about a given point using Taylor's formula.
CO3	Able to determine a given real valued function of two variables is continuous/ differentiable at a given point.
CO4	Find constrained extremum of a given function of several variables by using Lagrange's Method of Multipliers.
CO5	Evaluate given line and surface/multiple integrals.
CO6	Determine convergence/divergence of a given sequence and series of real numbers.

Syllabus:

Differential Calculus: Limit and Continuity of functions defined on intervals, Intermediate Value theorem, Differentiability, Rolle's Mean Value Theorem, Lagrange's Mean Value Theorem, Cauchy's Mean Value Theorem, Indeterminate Forms, Taylor's Theorem and Taylor's series.

Functions of Several Variables: Limit and Continuity, Geometric representation of partial and total increments, Partial derivatives, Derivatives of composite and implicit functions (Chain Rule), Change of Variables (Jacobian), Gradient, Lagrange's Multipliers Method for Maxima-Minima, Directional derivatives, Gradient vectors, Tangent plane.

Integral Calculus: Definite integral as the limit of sum, Mean value theorem of integrals, Fundamental theorem of integral calculus and its applications, Differentiation under Integral Sign.

Multiple Integrals: Evaluation of double integral in cartesian and polar coordinates, Change of order of integration, Change of Variables, Line integrals, Surface integrals.

Sequences and Series: Sequences of real numbers, Convergence of sequences, Subsequences, Monotone Sequences and their convergence, Cauchy Sequence, Cauchy criterion for convergence of a Sequence, Series of real numbers, Convergent of a Series, Comparison test, Limit Comparison test, D'Alemberts test (Ratio test), Raabe's test, Root test, Integral test for the convergence of series, Alternating series, Leibnitz theorem, absolute and conditional convergence

Text Book(s):

1. Thomas. G.B, and Finney R.L, Calculus, Pearson Education, 2007

References & Web Resources:

1. Piskunov. N, Differential and Integral Calculus, Vol. I &II, Mir. Publishers, 1981.
2. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House, 2005.
3. J Hass, M D Weir, F R Giordano, Thomas Calculus, 11th Edition, Pearson, 2005.

Course Title	Course Code	Structure (I-P-C)		
Engineering Mechanics	**DS102**	**3**	**0**	**3**

Pre-requisite: Nil

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

CO1	Find units and dimensions of physical properties.
CO2	Draw free body diagrams, study the dynamics of an object and predict the subsequent motion.
CO3	Use polar coordinates to describe rotational motion of an object.
CO4	Understand the planetary motion and gravitation.
CO5	Apply the concepts of angular momentum and torque for rigid body dynamics.

Syllabus

Vectors, uniform and accelerated motion, kinematic equations, inertia, Newton's Laws, free-body diagrams, equations of motion, some applications of newton's laws: Free and forced vibration, damped and undamped vibration, Friction: Sliding friction analysis on wedge, belt; Rolling resistance.

Virtual work method: Principle of virtual work, Stability of Equilibrium

Dynamics of system of particles, motion in a plane, conservation of linear momentum, centre of mass, Centre of Gravity, Moment of Inertia, work energy theorem, potential energy, energy diagrams, Stability analysis, Small Oscillations, Simple Harmonic Motion.

Angular momentum and fixed axis rotation, rigid body dynamics, Conservation of angular momentum, Euler's equations, Gyroscope motion and its applications.

Textbook and References:

1. F. Beer. R. Johnston, Vector mechanics for engineers: statics and dynamics. Tata McGraw-Hill, 2010.
2. Meriam. J. L and Kraige. L. G, Engineering Mechanics, Vol. I – Statics, Vol 2: Dynamics, 2007.
3. Daniel Kleppner and Rober Kolenkow, An introduction to Mechanics, MeGraw Hill Education, 2017.
4. T W B Kibble, Frank H. Berkshire, Classical Mechanics, Imperial College Press, 2004.
5. Somnath Datta, Mechanics, Pearson education India, 2012.
6. A P French, Newtonian Mechanics, Viva Books, 2017.

Course Title	Course Code	Structure (I-P-C)		
Technical and Professional Communication	**DS103**	**2**	**2**	**3**

Pre-requisite: Nil

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

CO1	Improve their speaking skills.
CO2	Improve their writing skills.
CO3	Improve their reading skills.
CO4	Improve their listening skills.
CO5	Use English language confidently.
CO6	Improve their Presentation Skills.

Syllabus:

Fundamental Skills in English Communication

Productive Skills:

Speaking - Self Introduction, Introducing Others, Giving and asking directions, Pronunciation – MTI Influence, Fluency and Accuracy, Para-Linguistics, Chronemics, Role-Play, Oral Presentation and Public speaking.

Writing - Cohesion and Coherence in writing, Punctuation, Writing for specific purposes, Official Letters, Business Letters, Report-writing, Precise-writing E-mail writing and Statement of Purpose.

Receptive Skills:

Reading - Reading Comprehension, Techniques and Strategies for Effective Reading, Skimming, Scanning, Intensive Reading, Extensive Reading, Horizontal Reading, Vertical Reading, Inferential Reading and Advanced Reading Comprehension.

Listening - Active Listening, Attentive Listening and Reflection, Strategies for Note Taking/ Making while Listening, Mind Mapping, List-Bullets, Map, Tree Diagram, Pyramid, Pie-Chart, Graphical Representation and Interpretation.

English for Employability

Resume/CV Writing, Mechanics of Writing, Interview Skills – Direct, Video and Telephonic, Telephone Etiquette, E-mail Etiquette, Video-Interview Etiquette, Empathy/Sympathy, Group Discussion, Thematic Apperception Test, Presentation Skills, Leadership Skills, Inter-Personal Skills, Analytical Skills, Problem-Solving, Decision Making, Critical thinking, Non-Verbal Communication, Negotiation Skills and Mock-Interviews.

Fundamental Skills in English Communication – Practice

1. Reading Comprehension Tasks

2. Listening Comprehension Tasks
3. Practicing Writing Emails/Reports/Letters
4. JAM/Group Discussion/Public Speaking
5. Pair work/Group work and Collaboration

English for Employability – Practice

a. Practicing Presentation Skills
b. Critical Thinking Activities
c. Inter-personal/Leadership/Problem Solving/Analytical /Decision Making Activities
d. Practicing Telephonic Interviews/Video Interviews and Direct Interviews
e. Mock-Interviews

Text Book(s):

1. Sanjay. K & Pushp. L. *English Language and Communication Skills for Engineers*, OUP, 2018.
2. Suresh. K. E. *Engineering English*, The Orient Blackswan, 2014.

Reference Book(s):

1. Arosteguy, K.O. and Bright, A. and Rinard, B.J. and Poe, M. *A Student's Guide to Academic and Professional Writing in Education*, UK, Teachers College Press, 2019.
2. Raymond, M. *English Grammar in Use A Self-Study Reference and Practice Book for Intermediate Learners of English*. Cambridge University Press, 2019.
3. Beatty, K. *Computer Assisted Language Learning*. London: Longman, 2010.
4. Catherine, N. & Brigitte, P. *Introducing Business English.* Routledge, 2016.
5. Meenakshi, R. & Sangeetha, S. *Professional English.* OUP, 2018.

Course Title	Course Code	Structure (I-P-C)		
Earth, Environment and Design	**DS104**	**2**	**0**	**0**

Pre-requisite, if any: Nil

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

CO1	Understand the basics of environmental issues relevant to the development of modern technology.
CO2	Know the principles behind modern eco-system.
CO3	Understand the concept of sustainable development.
CO4	Have awareness about various environmental policies and allied socio-economic issues.

Syllabus:

Introduction to environment and ecology – Ecosystems – Principles concepts, components and function, Atmospheric, aquatic and terrestrial ecosystems – Biogeochemical cycles and limiting factor concepts –Impacts of natural and human activities on ecosystems.

Environmental policies, acts and standards – Sustainable development and environmental impact assessment – Institutional frame work and procedures for EIA
Methods for impact identification-matrices – Networks and Check lists – Environmental settings, indices and indicators.

Prediction and assessment of the impacts on air, water, land, noise and biological environments – Assessment of impacts of the cultural, socioeconomic and eco-sensitive environments.

Mitigation measures, economic evaluation – Public participation and design making – Preparation of Environmental statement

Text Book(s):

1. Rubin. E. S, Introduction to Engineering and the Environment, McGraw Hill, 2000.
2. Masters. G. M., Introduction to Environmental Engineering & Science, Prentice Hall,1997.

References & Web Resources:

1. Henry. J. G, and Heike, G. W, Environmental Science & Engineering, Prentice Hall International, 1996.
2. Dhameja. S. K, Environmental Engineering and Management, S. K. Kataria and Sons, 1999.
3. Shyam Divan and Armin Rosancranz, Environmental Law and Policy in India, Cases, Materials and Statutes, Oxford University Press, 2001.

Course Title	Course Code	Structure (I-P-C)		
Engineering Mechanics Practice	**DS105**	**0**	**3**	**2**

Pre-requisite, if any: Nil

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

CO1	Estimate errors and work out propagation of errors through formulae.
CO2	Understand the concept of controlled experimentation.
CO3	Verify Newton's laws, Conservation of Linear Momentum, coefficient of static friction, etc.
CO4	Determine the moment of Inertia, Young's modulus, Rigidity Modulus, etc.

Syllabus:

Experiments here will give hands on experience of concepts of small oscillations, friction, verification of newton's laws, determination of gravitational constant, etc.

Experiments will be done to measure various properties of different mechanical objects such as rigidity modulus, Young's modulus, radius of gyration, propagation material waves, etc.

Text Book and References:

1) IIITDM Kurnool Laboratory manual for Engineering Mechanics Practice.

2) F. Beer. R. Johnston, Vector mechanics for engineers: statics and dynamics. Tata McGraw- Hill, 2010.

3) Callister's Materials Science and Engineering, 2nd ED, Adapted by R Balasubramaniam, 2010, Wiley India Ltd.

Course Title	Course Code	Structure (I-P-C)		
Measurements and Data Analysis	**DS106**	**0**	**3**	**2**

Pre-requisite, if any: Nil

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

CO1	Understand the basics of statistical analysis in experimental research.
CO2	Understand the error/uncertainty in data collection and analysis.
CO3	Understand and Analyze data interpretation.
CO4	Acquire and handle large data sets in experiments.

Syllabus:

Role of Experiments and measurements: Evaluation of different measurement techniques in measurement of various physical/chemical/mechanical/electrical/thermal/environmental parameters.

Reporting Methodology: Collection, consolidation and reporting of the data

Probability and Statistics: Presentation, analysis and interpretation of the data

Uncertainty/Error Analysis: Performance evaluation and determination

Signal Characterization, data acquisition and Analysis: Study of vivid waveforms and digitization Process.

Text Book(s):

1. Patrick F. Dunn, “Measurement and Data Analysis for Engineering and Science”, First Edition, McGraw-Hill Book Company, 2005.

References & Web Resources:

1. Julius S. Bendat, Allan G. Piersol, “Random Data: Analysis and Measurement Procedures”, 4th Edition, Wiley, 2010
2. Anthony J. Wheeler, Ahmad Reza Ganji, “Introduction to Engineering Experimentation” 3rd Edition, Prentice Hall, 2010

Course Title	Course Code	Structure (I-P-C)		
Differential Equations	**DS107**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Solve linear ordinary differential equations with constant coefficients of given order.
CO2	Find power series solution of second order linear ordinary differential equations about a given regular point/regular singular point.
CO3	Solve Bessel's and Legendre's differential equations.
CO4	Find Fourier series of a given periodic function.
CO5	Apply Laplace Transform method to solve the problems arise in engineering.
CO6	Solve given second order partial differential equations by using variable separable method.

Syllabus:

ODE: Higher order linear differential equations with constant coefficients, homogeneous and non-homogeneous, operator method, Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations.
Power series solution of ordinary differential equations and Singular points,
Bessel and Legendre differential equations; properties of Bessel functions and Legendre Polynomials.
Fourier Series: Expansion of a function in Fourier series for a given range, Half range sine and cosine expansions.
Laplace Transforms: Elementary properties of Laplace transforms, inversion by partial fractions, convolution theorem and its applications to ordinary differential equations.
PDE: Introduction and classification of second order partial differential equations, wave equation, heat equation, Laplace equation and their solutions by the method of variable separable.

Text Book(s):

1. Ordinary and Partial Differential Equations, M. D. Raisinghania, S. Chand Publishers, New Delhi 19th edition, 2017.
2. Simmons. G.F, Differential Equations, Tata McGraw Hill, 2003.

References & Web Resources:

1. Engineering Mathematics, John Bird, 7th edition, Routledge, Taylor & Francis Group, 2014.
2. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House, 2005.
3. Ross. L.S, Differential Equations, Wiley, 2007.

Course Title	Course Code	Structure (I-P-C)		
Engineering Electromagnetics	**DS108**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Apply vector calculus for solving problems involving electrostatics
CO2	Calculate electric field and potential for various continuous and discrete charge distributions.
CO3	Apply Biot Savart law to calculate Magnetic Induction.
CO4	Understand magnetic fields in matter and physics behind different types of magnetic materials.

Syllabus:

Electrostatics: Brief review of vectors, Gradient of a scalar field, divergence of a vector, Unit vectors in spherical and cylindrical polar coordinates, Gauss's theorem, Stokes's theorem, The Electric Field, Divergence and curl of electrostatic fields, potential and its relation with electrostatic Field, The energy of a continuous charge distribution, conductors and induced charges, Laplace's and Poisson's Equation for electrostatics, uniqueness theorems, The Method of Images, Multipole expansion, numerical methods to solve Laplace's and Poisson's Equation.

Electric Fields in Matter: Materials in electric field- Conductors-Dielectrics, the field of a polarized object, bound charges, Electric Displacement-Gauss's Law in the Presence of Dielectrics, Susceptibility, Permittivity, dielectric constant, Dielectric strength, Electric flux density, Energy in Dielectric Systems.

Magneto statics: The Lorentz Force Law, Continuity equation, The Biot-Savart Law, The Divergence and Curl of magnetic field, Magnetic Induction due to configurations of current carrying conductors, Magnetic Vector Potentials, Ampere's Circuit law, Energy density in a Magnetic field.

Magnetic Field in Matter: Magnetic Properties of Materials- Magnetic Dipole, Torques and Forces, Magnetic Permeability and Susceptibility, Magnetic Circuit-Forces in Magnetic Field, Magnetization- Dia, Para, ferromagnetism, Effect of a magnetic field on atomic orbits, Bound Currents, Hysteresis loop in ferromagnetic materials.

Text Book and References:

1) W. H. Hayt and J. A. Buck, Engineering Electromagnetics, Tata McFraw Hill Education Pvt. Ltd, 2006.
2) Grifiths. D. J, Introduction to Electrodynamics, Prentice Hall, 2007.
3) Purcell. E.M, Electricity and Magnetism Berkley Physics Course, V2, Tata McGraw Hill, 20 08.
4) Feynman. R.P, Leighton. R.B, Sands. M, The Feynman Lectures on Physics, Narosa Publishing House, Vol. II, 2008. Hill, 2008.

5) G. B. Arfken, H. J. Weber and F. E. Harris, Mathematical Methods for Physicists, Academic Press, 2013.

Course Title	Course Code	Structure (I-P-C)		
Engineering Electromagnetics Practice	**DS109**	**0**	**3**	**2**

Pre-requisite, if any:

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

CO1	Estimate errors and work out propagation of errors through formulae.
CO2	Understand the concept of controlled experimentation.
CO3	Calculate equipotential lines.
CO4	Calculate the electric and magnetic properties of materials.
CO5	Calculate the low resistance of the wire, etc.
CO6	Demonstrate the electromagnetic induction.

Syllabus:

Experiments to calculate the equipotential lines, dielectric properties of materials, eddy currents. Fourier series using LCR circuit. Carey foster bridge.

Experiments to verify the Biot-Savart law, ampere's law, field along and off the axis of the coil using hall probe, etc. Experiments to characterize the magnetic properties of materials based on the concept of magnetization. B-H Curve.

Text Book and References:

1) IIITDM Kurnool Laboratory manual for Engineering Electromagnetics Practice.
2) W. H. Hayt and J. A. Buck, Engineering Electromagnetics, Tata McFraw Hill Education Pvt. Ltd, 2006.

Course Title	Course Code	Structure (I-P-C)		
Design History	**DS111**	**2**	**0**	**2**

Pre-requisite, if any: Nil

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

CO1	Understand the evolution and application of the concept of Design in everyday life of people.
CO2	Appreciate its role in national and international economic and social systems.
CO3	Analyze the emerging designs from a societal perspective.

Syllabus:

Definition of Design; Origin of designers; Historical context of design and designers.
Designers and designed products: Art, design and technology - Select International and Indian designers. Industrial Revolution: Mass production, Birth of Modern architecture, International Style, The modern home.
Craft and Design: Type forms; William Morris and Arts and Craft Movement; Shantiniketan.
Design movements: Art Nuoveau; Art Deco, Werkbund; Bauhaus; De Stijl. Changing values
Information Revolution: Impact of technology, industrialization and globalization on design: kitsch, pastiche, 'retro'; Shopping malls.
Design Studies: Materials and techniques; Chinese ceramics; Typology; Content analysis: Anthropology / sociology; Nationalist and global trends in Design; Nationalist Design;
Global trends and global identity; Nostalgia, Heritage and Design;

Text Book(s):

1. Conway Hazel, Design History – A Students' Handbook, Routledge: London, 1987.

References & Web Resources:

1. Raizman David, History of Modern Design, Graphics and Products since the Industrial Revolution. Laurence King Publishing: London, 2003
2. Walker John. A, Design History and History of Design. Pluto Press: London, 2003.
3. Woodham Jonathan M, Twentieth Century Design, Oxford University Press: Oxford, 2003.

Course Title	Course Code	Structure (I-P-C)		
History of Science and Technology in India	**DS112**	**2**	**0**	**2**

Pre-requisite, if any: Nil

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

CO1	Understand historical development of Science and Technology in India starting from Ancient Period.
CO2	Understand the Science and Technology of Ancient India.
CO3	Understand development of Science and Technology in Medieval Period.
CO4	Analyze and understand Modern development of Scientific Intuitions, Scientific Temper.
CO5	Conduct relevant case studies.

Syllabus:

Ancient History

Science and Technology in the age of Harappa and Indus valley civilizations, Science in Vedic and Post Vedic period, Development of Mathematics, Astronomy, Medicine, etc.

Medieval period

Mathematics, Astronomy, Medicine, Textile, Art & Architecture, Irrigation, Materials & metallurgy, etc.

Modern Period

Modern Scientific institutions, Scientific temper, Science Popularization movements, Atomic Energy, Space Science, Agriculture, etc.

Case Studies

Text Book(s) and References:

1. Bernal, J. D. (1969). Science in history: Vol. 1-4.
2. Narlikar, J. V. (2003). The scientific edge: The Indian scientist from vedic to modern times.
3. Habib, I. (2020). Technology in Medieval India, Tulika Books.
4. Mahesh, V. S. (2011). Science and Technology in Ancient India, Centrum Press.
5. Kamlesh, M. (2014). Science and Technology in Colonial India, Aakar Books.

Course Title	Course Code	Structure (I-P-C)		
Professional Ethics for Engineers	**DS121**	**2**	**0**	**0**

Pre-requisite, if any: Nil

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

CO1	Understand the difference between morals and ethics.
CO2	Understand the concept of Professional Ethics.
CO3	Improve their integrity and morality.
CO4	Differentiate between good and bad practices.

Syllabus:

Professionalism and Ethics: Profession and occupation, Qualities of a professional practitioner,
Variety of ethics and moral issues, moral dilemmas; Kohlberg's theory - Gilligan's theory of moral development - consensus and controversy. Values- concept of intrinsic good, instrumental good and universal good. Kant's theory of good action and formula for universal law of action. Codes of ethics for engineers: need and scope of a code of ethics; Ethics and Law

Understanding Ethical Problems: ethical theories – utilitarianism, cost-benefit analysis, Duty ethics - Right ethics and virtue ethics. Applications for various case studies.

Ethical Problem Solving Techniques: issues-factual, conceptual and moral; Bribery and acceptance of gifts; Line drawing and flow charting methods for solving conflict problem.
Risk, Safety and Accidents: Safety and risk, types of risk, types of accidents and how to avoid
accidents.
Rights and Responsibilities of an Engineer: Professional responsibility, professional right and whistle blowing. Ethical Issues in Engineering Practice: environmental ethics, computer ethics, ethics and research.

Text Book(s):

1. Charles D. Fleddermann, "Engineering Ethics", Pearson Education / Prentice Hall, New Jersey,2004.

References & Web Resources:

1. Charles E Harris, Michael S. Protchard and Michael J Rabins, "Engineering Ethics – Concepts and Cases", Wadsworth Thompson Leatning, United States, 2000.
2. Velasquez. M. G, Business Ethics and Cases, 5 Edn, Prentice Hall, 2002.
3. Sekha. R.C, Ethical Choices in Business Response, Sage Publication, 2002.
4. Mike Martin and Roland Schinzinger, Ethics in Engineering, McGraw Hill, 1996.

Course Title	Course Code	Structure (I-P-C)		
Universal Human Values	**DS122**	**2**	**0**	**0**

Pre-requisite: Nil

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

CO1	Understand basic universal human values.
CO2	Understand the concepts of harmony, health and prosperity.
CO3	Analyze and understand the value of human relations with family and society.
CO4	Understand concepts such as harmony in nature and existence in relation to ethics will be introduced.

Syllabus:

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education
Purpose and motivation for the course, recapitulation from Universal Human Values Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario Method to fulfil the above human aspirations: understanding and living in harmony at various levels.
Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

Understanding Harmony in the Human Being - Harmony in Myself!
 Understanding human being as a co-existence of the sentient 'I' and the material 'Body' Understanding the needs of Self ('I') and 'Body' - happiness and physical facility Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer) Understanding the characteristics and activities of 'I' and harmony in 'I' Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail Programs to ensure Sanyam and Health.
Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.

Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship
Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship Understanding the meaning of Trust; Difference between intention and competence Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship Understanding the harmony in the society (society being an extension of family): Resolution,

Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals ˚ Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

˚ Understanding the harmony in the Nature ˚ Interconnectedness and mutual fulfilment among the four orders of nature recyclability and self-regulation in nature ˚ Understanding Existence as Co-existence of mutually interacting units in all- pervasive space ˚ Holistic perception of harmony at all levels of existence.

Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Implications of the above Holistic Understanding of Harmony on Professional Ethics

Natural acceptance of human values ˚ Definitiveness of Ethical Human Conduct ˚ Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order ˚ Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. ˚ Case studies of typical holistic technologies, management models and production systems ˚ Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations ˚ Sum up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions eg. To discuss the conduct as an engineer or scientist etc.

Text Book(s):

1. R R Gaur, R Asthana, G P Bagaria, "A Foundation Course in Human Values and Professional Ethics", 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93- 87034-47-1.
2. R R Gaur, R Asthana, G P Bagaria, "Teachers' Manual for A Foundation Course in Human Values and Professional Ethics", 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2.

Reference Book(s):

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amar kantak, 1999.
2. A. N. Tripathi, "Human Values", New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. Mohandas Karamchand Gandhi "The Story of My Experiments with Truth".
5. E. FSchumacher. "Small is Beautiful".
6. Slow is Beautiful –Cecile Andrews.
7. J C Kumarappa "Economy of Permanence".
8. Pandit Sunderlal "Bharat Mein Angreji Raj".
9. Dharampal, "Rediscovering India".

10. Mohandas K. Gandhi, “Hind Swaraj or Indian Home Rule”.
11. India Wins Freedom - Maulana Abdul Kalam Azad.
12. Vivekananda - Romain Rolland (English).
13. Gandhi - Romain Rolland (English).

Course Title	Course Code	Structure (I-P-C)		
Basic Electrical and Electronics Engineering	**EC101**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Develop and employ circuit models for elementary electronic components and circuit analysis.
CO2	Design the electric circuits with passive components.
CO3	Analyze the voltage and current of an electric circuit.
CO4	Understand various network theorems of an electric circuit.
CO5	Understand PN junction diode and BJT.

Syllabus:

Electrical circuit elements: voltage and current sources, R,C,L,M,I,V, linear, non-linear, active and passive elements, inductor current and capacitor voltage continuity, Kirchhoff's laws, Elements in series and parallel, superposition in linear circuits, controlled sources, energy and power in elements, energy in mutual inductor and constraint on mutual inductance.

Network analysis: Nodal analysis with independent and dependent sources, super nodal analysis, mesh analysis, super mesh analysis.

Network theorems: superposition theorem, substitution theorem, Millman's theorem, Tellegen's theorem, reciprocity theorem, Thevenin's and Norton's theorems, pushing a voltage source through a node, splitting a current source, compensation theorem, maximum power transfer theorem.

RC and RL circuits: natural, step and sinusoidal steady state responses, series and parallel RC/RL/RLC circuits, steady state and transient response, resonance.

Two port network functions: z, y, h, g, T, and t parameters; conversion of one parameter to another, condition for the reciprocity and symmetry.

Fourier and Laplace analysis of electric circuits.

Network topology: notion of network graphs, nodes, trees, twigs, links, co-tree, independent sets of branch currents and voltages, incidence matrix, tie set matrix, cut set matrix

AC signal measures: complex, apparent, active and reactive power, power factor. Magnetic circuits: self-inductance, mutual inductance, dot convention, series/parallel connection of coils

Introduction to three phase supply: three phase circuits, star-delta transformations, balanced and unbalanced three phase load, power measurement, two wattmeter method.

Semiconductor diodes and application: PN diodes, rectifiers and filters, clipping and clamping circuits, voltage multiplier circuits.

Text Book(s):

1. Hayt. W. W, Kemmerly. J.E, and Durbin. S.M, Engineering Circuits Analysis, 8th edition, Tata McGraw Hill, 2013.

2. J. David Irwin and R. Mark Nelms, Basic Engineering Circuit Analysis, 10th edition, Wiley, 2011

References & Web Resources:

1. Hughes Edward, Electrical & Electronic Technology, 10th edition, Pearson Education, 2007.

2. Hambley. A, Electrical Engineering Principles and Applications: International Version, Pearson Education, 4 Edn, 2007.

3. Alexander.C. K. & Mathew. N. O. Sadiku, Fundamentals of Electrical circuits, 5th edition, Tata McGraw Hill, 2008

Course Title	Course Code	Structure (I-P-C)		
Problem Solving and Computer Programming	**CS101**	**3**	**0**	**3**

Pre-requisite: Nil

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

CO1	The course introduces students to computer systems and organization and a higher level language (C) to communicate with the system.
CO2	The student would be equipped with basic skillset required to interact with the system / create applications supporting a command line interface.
CO3	Interpret the basic principles of C Programming.
CO4	Understand decision making and looping concepts.
CO5	Design and develop modular programming (using functions).
CO6	Understand usage of Arrays, strings, structures and files.
CO7	Effective utilization of pointers and preprocessor directives.
CO8	Design and implement programs which require manipulation of pointers

Syllabus:

Basic computer organization, operating system, editor, compiler, interpreter, loader, linker, program development. Variable naming, basic function naming, indentation, usage and significance of comments for readability and program maintainability. Types of errors, debugging, tracing/stepwise execution of program, watching variables values in memory. Character Set, C tokens, Keywords and Identifiers, Constants, Variables, Data types, Declaration of Variables, Assigning values to variables, typedef, and Defining symbolic constants. printf & scanf functions.

Operators and Expression Introduction, Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Increment and Decrement Operators, Conditional Operators, Special Operators, Evaluation of expressions, Precedence of arithmetic operators, Type conversions in expressions, Operator precedence and associativity. Reading a character, writing a character, formatted input, and formatted output.

Decision making with IF statement, the IF.. ELSE statement, nesting of IF .. ELSE statements, IF .. ELSE ladder, switch statement, ternary operator, GOTO statement. WHILE statement, DO .. WHILE statement, FOR statement, Break and Continue.

One-dimensional arrays, Two-dimensional arrays, arrays, Concept of Multidimensional arrays. Declaring and initializing string variables, Reading string from terminal, Writing string to screen, atoi(), string functions: String Copy, String Compare, String Concatenation, String Length (using predefined functions & without using them), array of strings.

Need for user-defined functions (UDF), The format of a C function, elements of UDF, Return values and their types, Calling a function, category of functions, Nesting of functions, Recursion, Functions with arrays, The scope and Lifetime of variables in functions. n, Structure definition, declaring and initializing Structure variables, accessing Structure members, Copying & Comparison of structures, Arrays of structures, Arrays within structures, Structures within Structures, Structures and functions, Unions.

Understanding pointers, Accessing the address of variable, Declaring and initializing pointers, Accessing a variable through its pointer, Pointer expressions, Pointer increments and scale factor, Pointers and arrays, Pointers & character strings, Pointers & Functions, Function returning multiple values, Pointers and structures. Defining files and its Operations, Error handling during I/O operations, Random access files, Command line arguments. Types of files, File vs. Console, File structure, File attributes, Standard i/o, Formatted i/o, Sample programs.

Textbooks:

2. Deitel P J and Deitel H M, C : How To Program, Prentice Hall, 7th Edn, 2012.
3. Kernighan, Ritchie D, The C Programming Language, Prentice Hall, 2 Edn.

Reference books:

1. Kernighan, Ritchie D, The C Programming Language, Prentice Hall, 2 Edn.
2. Chapra S.C and Canale R.P, Numerical Methods for Engineers, McGraw Hill, 2006.

Course Title	Course Code	Structure (I-P-C)		
Problem Solving and Computer Programming Practice	**CS102**	**0**	**3**	**2**

Pre-requisite: Nil

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

CO1	The course introduces students to computer systems and organization and a higher level language (C) to communicate with the system.
CO2	The student would be equipped with basic skillset required to interact with the system / create applications supporting a command line interface.
CO3	Interpret the basic principles of C Programming.
CO4	Understand decision making and looping concepts.
CO5	Design and develop modular programming (using functions).
CO6	Understand usage of Arrays, strings, structures and files.
CO7	Effective utilization of pointers and preprocessor directives.
CO8	Design and implement programs which require manipulation of pointers

Syllabus:

Introduction to programming Environment (Linux commands, editing tools such as vi editor, sample program entry, compilation and execution)

Development of programs using multiple arithmetic and logical operators. Programs for Roots of quadratic equation, conversion of units etc.

Programs using simple control statements such as if else, while, do while etc. Making a program for a calculator for example. Extracting the digits of an integer, reversing digits, finding sum of digits etc.

Programs using For loop, switch statement etc. eg. Finding average of numbers, printing multiplication tables etc. Checking for primes, generation of Armstrong numbers.

Generation of the Fibonacci sequence, Finding the square root of a number, calculation of factorials, printing various patterns using for loop. The greatest common divisor of two integers, Raising a number to large power

Programs using Arrays: declaring and initializing arrays. Program to do simple operations with arrays. Strings – inputting and outputting strings. Using string functions such as strcat, strlen etc. Writing simple programs for strings without using string functions.

Finding the maximum number in a set, Array order reversal, Finding maximum number from an array of numbers

Removal of duplicates from an ordered array, Selection/ Bubble/ Insertion sort

Create a linked list, traverse a linked list, insert a node and delete a node form the list.

Recursion and related examples such as Tower of Hanoi, computing factorial etc.

Textbooks:

2. Deitel P J and Deitel H M, C : How To Program, Prentice Hall, 7th Edn, 2012.
3. Kernighan, Ritchie D, The C Programming Language, Prentice Hall, 2 Edn.

Reference books:

1. Kernighan, Ritchie D, The C Programming Language, Prentice Hall, 2 Edn.

2. Chapra S.C and Canale R.P, Numerical Methods for Engineers, McGraw Hill, 2006.

Course Title	Course Code	Structure (I-P-C)		
Concepts in Engineering Design	**ME101**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Identify different types of engineering design.
CO2	Describe the life cycle of a product.
CO3	Apply conceptualization techniques in engineering design process.
CO4	Apply and validate different screening and testing methods.
CO5	Analyze the design and development of a product.

Syllabus:

Design Conceptualization and Philosophy, Original, Adaptive, Variant and Re-Design, Evolution of Concept, Need for Systematic design Past methods of and design.

Product life cycle, Innovation, Types of innovation

Needs and opportunities, Vision and Mission of a concept, Type of needs, Technology S - curve, Need analysis, market analysis and competitive analysis, Kano Diagrams, SWOT analysis

Conceptualization techniques – Idea generation – ideation, brainstorming, Trigger session Brain writing, Mind maps, SCAMPER, TRIZ, Biommicry, Shape mimicry, Familiarity Matrix

Concepts screening, Concept testing - exploratory tests, Assessment tests, Validation tests Comparison tests – Case studies

Organization of design concept and design methods, Engineering Design - Descriptive and prescriptive model, Design decisions and development of design

Group work and case studies

Text Book(s):

1. Otto. K and Wood, K, Product Design, Pearson Education, 2001.
2. Pahl. G and Beitz. G, Engineering Design, Springer, 1996.

References & Web Resources:

1. Ullman. D. G, The Mechanical Design Process, McGraw- Hill, 1997.

Course Title	Course Code	Structure (I-P-C)		
Science and Engineering of Materials	**ME102**	**3**	**0**	**3**

Pre-requisite, if any:

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

CO1	Identify and understanding of crystal structure
CO2	Describe different materials physical and chemical properties
CO3	Application of different materials for engineering structures
CO4	Estimate the development of natural and manmade materials, evolution based on application
CO5	Analyze the requirement of present industry, scope of application and provide novel solutions to existing problems.

Syllabus:

Crystal structure, defects, crystallographic planes, directions, slip, deformation mechanical behavior, and strengthening mechanisms.

Electrical, electronic, magnetic properties of materials, property management and case studies alloys, steel, aluminum alloys.

Polymeric structures, polymerization, structure property relationships, processing property relationships.

Natural and manmade composites, processing, properties, applications.

Ceramics, manufacturing and properties, applications.

Environmental degradation of engineering materials.

Introduction to Nano, Bio, Smart and Functional materials.

Text Book(s):

1. Callister's Materials Science and Engineering, 2nd ED, Adapted by R Balasubramaniam, 2010, ISBN-13: 978-8126521432, Wiley India Ltd.
2. V Raghavan, “Materials Science and Engineering: A First Course, 5th Ed, 2004, PHI India

References & Web Resources:

1. Donald R. Askeland K Balani, “The Science and Engineering of Materials,” 2012, Cengage Learning

2. Callister, W. D. (2000). Fundamentals of materials science and engineering (Vol. 471660817) London: Wiley.

Course Title	Course Code	Structure (I-P-C)		
Engineering Graphics	**ME103**	**0**	**3**	**2**

Pre-requisite, if any: Nil

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

CO1	Understand the importance of Drawing / Graphics in the Engineering
CO2	Understand the standards and conventions of the engineering drawing
CO3	Visualization of various basic shapes and create their projections
CO4	Creating orthographic views from Solids and Isometric views from views
CO5	Visualization and creation of sections, convolutions, involutes etc.

Syllabus:

1. Introduction to IS code of drawing
2. Construction of basic shapes
3. Dimensioning principles
4. Conventional representations
5. Orthographic projection of points, lines, planes, right regular solids & objects
6. Section of solids and objects
7. Isometric projection of objects
8. Intersection of solids
9. Development of surfaces

Text Book(s):

1. Narayana. K.L, and Kannaiah. P, Engineering Drawing, Charaotar Publ House, 1998.

2. Bhatt. N.D, Engineering Drawing, New Age International, 2007.

References & Web Resources:

1. Gopalakrishnan. K.R, Engineering Drawing, Subash Stores, 2002.

2. Natarajan. K.V, A text book of Engineering Drawing, Classic Prints, 2000.

Course Title	Course Code	Structure(I-P-C)		
Engineering Skills Practice	**ME104**	**0**	**3**	**2**

Pre-requisite, if any: Nil

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

CO1	Understand the basic manufacturing processes.
CO2	Accustom various joining processes.
CO3	Apply knowledge for assembling of simple circuits.
CO4	Design and fabrication of domestic wiring.
CO5	Analyze the cost of domestic and industrial wiring.

Syllabus:

Experiments will be framed to train the students in following common engineering practices:

Basic manufacturing processes: Fitting – Drilling & Tapping

Material joining processes – PCB making – Assembling and testing – Electrical wiring.

Familiarization of electronic components by Nomenclature, meters, power supplies, function generators and Oscilloscope

Bread board assembling of simple circuits: IR transmitter and receiver – LED emergency lamp – Communication study: amplitude modulation and demodulation

PCB: designing and making of simple circuits – Soldering and testing of electronic components and circuits

Various types of Domestic wiring practice: Fluorescent lamp connection, Staircase wiring

Estimation and costing of domestic and industrial wiring – power consumption by Incandescent, CFL and LED lamps.

Text Book(s):

1. Uppal S. L., “Electrical Wiring & Estimating”, 5Edn, Khanna Publishers, 2003.
2. Chapman. W. A. J., Workshop Technology, Part 1 & 2, Taylor & Francis.

References & Web Resources:

1. Clyde F. Coombs, “Printed circuits hand book”, 6Edn, McGraw Hill, 2007.
2. John H. Watt, Terrell Croft, “American Electricians' Handbook: A Reference Book for the Practical Electrical Man”, Tata McGraw Hill, 2002.

Course Title	Course Code	Structure (I-P-C)		
Design Realization	**ME105**	**0**	**3**	**2**

Pre-requisite, if any: Nil

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

CO1	Identify a real time problem.
CO2	Describe the methodology of solution, in terms of algorithm, or flowchart.
CO3	Application of product conceptualization in terms of making a simple product.
CO4	Estimate the development of full solution, and realize a prototype combining all domains of engineering and sciences.
CO5	Analyze the requirement of present industry, scope of application and scale up the prototype in redefining the solution in a large scale operation.

Syllabus:

The students are exposed to tools and equipments' to machine external appearance of products of simple shapes.

Wood carving, Plastic welding and cutting, engraving, sheet metal works, wire cutting are some of the process that the students will learn and use for product realization.

The students will also be exposed high end machines to realize the product during demo sessions. Few sessions will be allocated to re-design an existing simple products in terms of shape, size functionality etc.

The student s have to develop models, comprising of mechanical, electrical and computer peripheral units, addressing a problem.

The methodology of the problem should be clearly defined, additionally, a BOM, a design layout should be clearly specified. The product prototype should be developed, for a specific application and ensuring the scale up factor in consideration.

Text Book(s):

1. Tomovic, M. M., & Wang, S. (2009). Product Realization: A Comprehensive Approach. Springer.
2. Thornton, A. C. (2021). Product Realization: Going from One to a Million. John Wiley & Sons.

References & Web Resources:

1. Gerhard, J. F., Rosen, D., Allen, J. K., & Mistree, F. (2001). A distributed product realization environment for design and manufacturing. J. Comput. Inf. Sci. Eng., 1(3), 235-244.

Course Title	Course Code	Structure (I-P-C)		
Industrial Design Sketching	**ME106**	**0**	**3**	**2**

Pre-requisite, if any:

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

CO1	Develop necessary artistic skills required for the engineer to make communications with the industrial designers.
CO2	Train the students to make realistic sketches of concept design using the commercial concept sketching software and hardware.
CO3	This course will cover the concepts in perspective projections, shading, texturing, and concepts of light, shadow, reflection and colours.

Syllabus:

Role and importance of sketching in industrial design

Principles of perspective drawing

Perspective drawing of planar and curved shapes

Shading and texturing

Representation of shadow and reflections

Colours in Industrial design and colouring

Introduction to 3D forms and form development

Text Book(s):

1. Thomas C Wang, Pencil Sketching, John Wiley, 2002.

2. Itten Johannes, Design and Form, John Wiley, 1975.

3. Kasprin Ron, Design Media – Techniques for Water Colour, Pen and Ink Pastel and coloured markers, John Wiley,1999.

Second Year

Course Title	Course Code	Structure (I-P-C)		
Signals and Systems	**EC201**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Understand various properties of continuous time signals.
CO2	Analyze the frequency spectrum of continuous time signals.
CO3	Describe a LTI system by impulse/frequency response.
CO4	Analyze magnitude/phase response of various LTI systems.
CO5	Analyze systems commonly used in Communications, Control, and Signal Processing.

Syllabus:

Introduction to Continuous/Discrete time Signals and Systems: The unit impulse and unit step functions, Continuous-time signals, Transformations of the independent variables, Exponential and Sinusoidal signals, Continuous-time systems and basic system properties.

Linear Time-invariant Discrete/Continuous Systems: Continuous-time Linear Time-invariant (LTI) system, Discrete-time LTI system, Properties of LTI systems, System representation through linear constant coefficient differential equations.

Discrete/Continuous Fourier Series Representation of Periodic Signals: Fourier series representation of continuous/discrete time periodic signals, Convergence of the Fourier series, Properties of continuous/discrete time Fourier series, Fourier series and LTI systems, Filtering, Examples of continuous-time filters described by differential equations.

Discrete/Continuous-time Fourier Transform: Representation of aperiodic signals, The Fourier transform for periodic signals, Properties of the continuous-time Fourier transform, Convolution and multiplication properties and their effect in the frequency domain, magnitude and phase response.

Laplace Transform: The Laplace transform for continuous-time signals and systems, the notion of Eigen value and Eigen functions of LTI systems, Region of convergence, System

functions, Poles and zeros of system functions and signals, Properties of the Laplace transform, Analysis and characterization of LTI systems using the Laplace transform, The unilateral Laplace transform.

Z-transform: Introduction of z-transform, Properties of the region of convergence of the z-transform, The inverse z-transform, Properties of the z-transform, solving the difference equations using Z-transform.

Text Book(s):

1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, "Signals and Systems," 2nd Edition, Prentice Hall, 2003.

2. S. Haykin and B. V. Veen, "Signals and Systems" 2nd Edition, Wiley, 2007.

References & Web Resources:

1. B.P. Lathi, "Principles of Linear Systems and Signals," Oxford University Press, 2nd Edition, 2009.

Course Title	Course Code	Structure (I-P-C)		
Electronic Devices	**EC202**	**3**	**0**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engineering

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

CO1	Understand the principles and characteristics of different types of semiconductor devices.
CO2	Understand the fabrication process of semiconductor devices.
CO3	Utilize the mathematical models of semiconductor junctions and MOS transistors for circuits and systems
CO4	Understand the constructional details and characteristics of BJT and MOS Devices.

Syllabus:

Semiconductor Basics: Bonding forces, Energy bands in Solids, Metals, Semiconductors and Insulators, Direct and Indirect semiconductors, Electrons and Holes, Intrinsic and Extrinsic materials, Conductivity and Mobility, Drift and Resistance, Effects of temperature and doping on mobility, Hall Effect.

P-N Junctions: Forward and Reverse biased junctions- Qualitative description of Current flow at a junction, reverse bias, Reverse bias breakdown- Zener breakdown, avalanche breakdown, Rectifiers, Optoelectronic Devices Photodiodes: Current and Voltage in an Illuminated Junction, Solar Cells, Photo detectors. Light Emitting Diode: Light Emitting materials.

Bipolar Junction Transistor: Fundamentals of BJT operation, Amplification with BJTS, BJT Fabrication, The coupled Diode model (Ebers-Moll Model), Switching operation of a transistor, Cutoff, saturation, switching cycle, specifications, Drift in the base region, Base narrowing, Avalanche breakdown.

Field Effect Transistors: Basic JFET Operation, Equivalent Circuit and Frequency Limitations, MOSFET Two terminal MOS structure- Energy band diagram, Ideal Capacitance – Voltage Characteristics and Frequency Effects, Basic MOSFET Operation-MOSFET structure, Current-Voltage Characteristics.

Fabrication of P-N Junctions: Thermal Oxidation, Diffusion, Rapid Thermal Processing, Ion implantation, chemical vapour deposition, photolithography, Etching, metallization.

Integrated Circuits: Background, Evolution of ICs, CMOS Process Integration, Integration of Other Circuit Elements.

Text Book(s):

1. Ben. G. Streetman, Sanjay Kumar Banergee, “Solid State Electronic Devices”, 7th Edition, Pearson Education.

2. Donald A Neamen, Dhrubes Biswas, “Semiconductor Physics and Devices”, 4th Edition, MCGraw Hill Education, 2012.

References & Web Resources:

1. S. M. Sze, Kwok K. Ng, “Physics of Semiconductor Devices”, 3rd Edition, Wiley, 2018.

Course Title	Course Code	Structure (I-P-C)		
Digital Logic Circuits	**EC203**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Learn digital circuits
CO2	Design Combinational circuits
CO3	Design sequential circuits
CO4	Formulate logic and design circuits for practical problems.

Syllabus:

Representation of Data: Introduction, Data representations, Number systems, conversions and codes.

Switching Theory: Laws and theorems of Boolean algebra, switching functions, truth table and algebraic form, realization using logic gates.

Digital Logic and Implementation: K-Maps, QM method, SOP, POS; NAND and NOR implementation, Digital Circuit Characterization.

Combinational Circuit Design: Design Procedure, Multiplexer, Decoder, Encoder, Comparator, Seven-segment display, Parity generator, Design of large circuits, Ripple Carry Adder, Carry look ahead adder, carry save adder, carry save array multiplier, Wallace tree multiplier, Restoring/Non Restoring division techniques.

Asynchronous and Synchronous Sequential Circuit Design; Design of sequential modules – SR, D, T and J-K Flip-flops, applications, Clock generation, Clock dividers, Registers, and Counters.

Design using State machines: Moore and Mealy machines, Design Examples.

Issues at the Digital Circuits: Glitches, Glitch free circuit design, Static and Dynamic Hazards, Hazard resolution techniques, Race, and Cycles.

Text Book(s):

1. C. H. Roth, Jr., “Fundamentals of Logic Design,” 7th Edition, Cengage Learning, 2013.

2. S. Brown and Z. Vranesic, “Fundamentals of Digital Logic with VHDL Design,” TMH, 3rd Edition

References & Web Resources:

1. J. F. Wakerly, “Digital Design- Principles and Practices,” 3rd Edition, Pearson
2. M. M. Mano, “Digital Design,” PHI.
3. T. L. Floyd and R. P. Jain, “Digital Fundamentals,” 8th Edition, Pearson.

Course Title	Course Code	Structure (I-P-C)		
Fundamentals of Data structures and Algorithms	**CS210**	**3**	**0**	**3**

Pre-requisite, if any: Problem Solving and Computer Programming

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

CO1	Describe how arrays, records, linked structures, stacks, queues, trees, and graphs are represented in memory and used by algorithms.
CO2	Design efficient data structure which will be used by efficient algorithms to solve real problems.
CO3	Analyze the time complexity of various operations and algorithms.
CO4	Understand various search and sort algorithms.

Syllabus:

Review of Problem Solving using computers, Abstraction, Elementary Data Types: Algorithm design- Correctness via Loop invariants as a way of arguing correctness of programs, preconditions, post conditions associated with a statement.

Complexity and Efficiency via model of computation (notion of time and space), mathematical preliminaries, Elementary asymptotics (big-oh, big-omega, and theta notations).

Array -- searching and sorting on arrays: Linear search, binary search on a sorted array. Bubble sort, Insertion sort, Merge Sort and analysis; Emphasis on the comparison based sorting model. Counting sort, Radix sort, bucket sort.

Linked Lists, Stacks, Queues: List manipulation, insertion, deletion, searching a key, reversal of a list, use of recursion to reverse/search. Doubly linked lists and circular linked lists. (3 lectures) Stacks and queues as dynamic data structures implemented using linked lists. Analyze the ADT operations when implemented using arrays.

Binary Trees: Tree representation, traversal, application of binary trees in Huffman coding. Introduction to expression trees: traversal vs post/pre/infix notation. Recursive traversal and other tree parameters (depth, height, number of nodes etc.).

Dictionary: Binary search trees, balanced binary search trees - AVL Trees. Hashing - collisions, open and closed hashing, properties of good hash functions.

Priority queues: Binary heaps with application to in-place sorting.

Graphs: Representations (Matrix and Adjacency List), basic traversal techniques: Depth First Search + Breadth First Search (Stacks and Queues).

Text Book(s):

1. M. A. Weiss, “Data Structures and Algorithm Analysis in C++,” 2nd Edition, Pearson Education, 2002.

2. T. H. Cormen, C. E. Leiserson, and R. L. Rivest, “Introduction to Algorithms,” 2nd Edition, Prentice Hall India, 2001.

References & Web Resources:

1. Aho, Hopcroft, and Ullmann, “Data Structures and Algorithms,” Addison Wesley, 1983.

Course Title	Course Code	Structure (I-P-C)		
Linear Algebra	**DS201**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Analyze the solution set of a system of linear equations.
CO2	Generalize the concepts of a vector space
CO3	Investigate properties of vector spaces and subspaces using by linear transformations.
CO4	Show that they get clear understanding of methods of Linear Algebra.

Syllabus:

Linear System of Equations: Gaussian Elimination- echelon forms - existence, uniqueness and multiplicity of solutions of linear equations.

Vector Spaces: Definition-linear dependence and independence-spanning sets, basis, and dimension-definition of a subspace-intersection and sum of subspaces-direct sums.

Linear Transformations: Definition-matrix representation of a linear transformation-change of basis-similarity transformation-invertible transformation-system of linear equations revisited-the four fundamental subspaces associated with a linear transformation.

Inner Products: Definition-induced norm-orthogonality-Gram-Schmidt orthogonalization process-orthogonal projections-unitary transformations and isometry.

Eigen Decomposition: Eigenvalues and eigenvectorsp-characteristic polynomials and eigen spaces-diagonalizability conditions-invariant subspaces-spectral theorem.

Text Book(s):

1. G. Strang, “Linear Algebra and its Applications,” Cengage Learning, 4th Edition, 2005.

2. D. C. Lay, “Linear Algebra and its Applications,” Pearson Education, 4th edition, 2011.

References & Web Resources:

1. C. D. Meyer, “Matrix Analysis and Applied Linear Algebra,” SIAM, 2000.

2. S. H. Friedberg, A. J. Insel, and L. E. Spence, “Linear Algebra,” Pearson Education, 4th Edition, 2002.

Course Title	Course Code	Structure (I-P-C)		
Sociology of Design	**DS202**	**2**	**0**	**2**

Pre-requisite, if any: Nil

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

CO1	Design as a social activity involving people, their relationships & values - How designs can emerge out of or be constrained by social patterns of relating.
CO2	How technology can influence interactions among people, cooperative work, ethical issues around technology interventions.
CO3	Exposure to techniques like ethno methodology.

Syllabus:

Basics concepts of sociology (behavior, interaction, language)

Historical evolution of Societies (Agrarian, Industrial, Digital) and current human and organizational contexts in which engineers and other professionals work, Personal and corporate social responsibility & ethics.

Relationship between people (age, gender, cultures) and technology - Social and psychological dimensions of technological change, Technology & Work, Co-operative Work & Coordinative Practices, Ethno methodology, Critical Systems Heuristics.

Text Book(s):

1. Manuel Castells (1996); The Rise of Network Society.

2. Herbert Blumer (1986); Symbolic Interactionism: Perspective and Method.

References & Web Resources:

1. Herkert, J. (ed.), Social, Ethical, and Policy Implications of Engineering: Selected Readings. New York, NY: IEEE Press, 2000.
2. Heath, C. and Luff, P. (2000); Technology in Action, Cambridge: Cambridge University Press.
3. Werner Ulrich (1983), Critical Systems Heuristics, John Wiley,

Course Title	Course Code	Structure (I-P-C)		
Digital Logic Circuits Practice	**EC204**	**0**	**3**	**2**

Pre-requisite, if any: Nil

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

CO1	Learn digital circuits
CO2	Design Combinational circuits
CO3	Design sequential circuits
CO4	Formulate logic and design circuits for practical problems.

Syllabus:

Formulating Boolean expressions and truth tables from practical statements, designing logic diagrams, simplifying using k-map, designing NAND-NAND & NOR-NOR diagrams & verifying the same by simulation and experiment. Combinational circuits: code converters, arithmetic circuits, mux/demux, encoder/decoder, comparators etc.

Sequential circuits including flip flops, shift registers, counters, sequence generators etc.

Simple design examples with Moore and Mealy machines.

Digital circuits design using HDL

Text Book(s):

1. C. H. Roth, “Fundamentals of Logic Design,” 5th Edition, Thomson Books/Cole.

2. Samir Palnitkar: Verilog HDL - Guide to Digital design and synthesis, Pearson Guide to Digital design and synthesis, Pearson Education, 3rd Edn, 2003.

References & Web Resources:

1. S. Brown and Z. Vranesic, “Fundamentals of Digital Logic with VHDL Design,” TMH, 3rd Edition.

Course Title	Course Code	Structure (I-P-C)		
Fundamentals of Data structures and Algorithms Practice	**CS211**	**0**	**3**	**2**

Pre-requisite, if any: Problem Solving and Computer Programming

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

CO1	Describe how arrays, records, linked structures, stacks, queues, trees, and graphs are represented in memory and used by algorithms.
CO2	Design efficient data structure which will be used by efficient algorithms to solve real problems.
CO3	Analyze the time complexity of various operations and algorithms.
CO4	Understand various search and sort algorithms.

Syllabus:

The laboratory component will require the student to write computer programs using a careful choice of data structures (in C language) from scratch, based on the concepts learnt in the theory course.

Arrays: Linear and Binary search - Array and Pointer based implementation of list, stack and queue - Application of linked lists – Polynomial manipulations - Representing sets using lists and implementation of set theoretic operations - Expression conversion and evaluation of postfix expressions - Binary trees - binary search trees, AVL Trees and dictionary ADT using AVL trees- Heap and Priority queue ADT implementation using Heap –Hash tables.

Text Book(s):

1. M. A. Weiss, “Data Structures and Algorithm Analysis in C++,” 2nd Edition, Pearson Education, 2002.

2. T. H. Cormen, C. E. Leiserson, and R. L. Rivest, “Introduction to Algorithms,” 2nd Edition, Prentice Hall India, 2001.

References & Web Resources:

1. Aho, Hopcroft, and Ullmann, “Data Structures and Algorithms,” Addison Wesley, 1983.

Course Title	Course Code	Structure (I-P-C)		
Digital Signal Processing	**EC251**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems

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

CO1	Understand various properties of discrete-time signals
CO2	Analyze discrete time LTI systems, and their impulse responses
CO3	Synthesize discrete signals from analog signals
CO4	Reconstruct analog signals from discrete signals
CO5	Design the digital filters

Syllabus:

Review of Discrete-time Signals and Systems: Discrete-time signals: sequences, discrete-time systems, Linear time-invariant (LTI) systems, Properties of LTI systems, Linear constant coefficient difference equations, Frequency domain representation of discrete-time signals and systems, Representation of sequences by Fourier transforms, Symmetry properties of Fourier transform, Fourier transform theorems, Discrete-time random signals.

Transform Analysis of Linear Time Invariant Systems: The frequency response of LTI systems, System functions for systems characterized by linear constant-coefficient difference equations, Frequency response of rational system functions, Relationship between magnitude and phase, All-pass systems, Minimum phase systems.

Fast Fourier Transform: Introduction of the Discrete Fourier Transform (DFT), TheFourier transform of periodic signals, Properties of DFT, Linear convolution using the DFT. Efficient computation of the DFT, The Goertzel algorithms, Radix-2 decimation-in-time and decimation-in- frequency Fast Fourier Transform algorithms.

Structures for Discrete-Time Systems: Block Diagram Representation of Linear Constant-Coefficient Difference Equations, Signal Flow Graph Representation, Direct Forms, Cascade Form.

Filter Design Techniques: Analog filter design, Butterworth, Chebyshev filter technique. FIR filter design using Windowing and frequency sampling techniques. IIR filter design using impulse invariance and bilinear transformation, FIR and IIR filter structures.

Text Book(s):

1. A.V. Oppenheim, R.W. Schafer, and J. R. Buck, “Discrete-Time Signal Processing,” Pearson Education, 3rd Edition, 2010.

References & Web Resources:

1. S. K. Mitra, “Digital Signal Processing: A Computer-Based Approach”, 4th Edition, Tata Mcgraw Hill Publication, 2013.

2. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms and Applications”, Fourth edition, Pearson, 2007.

Course Title	Course Code	Structure (I-P-C)		
Analog Circuits	**EC252**	**3**	**0**	**3**

Pre-requisite, if any: Electronic Devices

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

CO1	Understand analog circuits.
CO2	Analyse and design of amplifiers viz. VCVS, VCCS, CCVS, CCCS. 3.
CO3	Analyse and design of analog circuits with operational amplifiers.
CO4	Analyse and design the analog filters

Syllabus:

Device Models: (diode, BJT, MOSFET); Small signal analysis of nonlinear circuits, small signal equivalent of diode, BJT, MOSFET.

Biasing: Adding dc bias to ac signals, Concept of ac coupling, current mirrors, Cascode current mirrors.

Basic transistor Amplifiers: small signal and large signal (low frequency) characteristics, VCVS, VCCS, CCVS, CCCS, high frequency effects.

Differential pair: Need of active load, differential amplifier.

OpAmp internal circuitry: 2-stage plus buffer example, Miller compensation of a 2-stage OpAmp, Stability, frequency compensation.

OpAmp circuits: Amplifier Circuits, Filters, oscillators.

Text Book(s):

1. B. Razavi, “Fundamentals of Microelecronics,” Wiley Student Edition, 2010.

2. S. Franco, “Design with Operational Amplifiers and Analog Integrated Circuits,” McGraw-Hill Series in Electrical and Computer Engineering, 4th Edition, 2015.

References & Web Resources:

1. Sedra and Smith, “Microelectronic Circuits,” 7 th Edition, Oxford University Press.

2. D. A. Newman, “Electronic circuits,” 4 th Edition, TMH.

Course Title	Course Code	Structure (I-P-C)		
Power Electronics	**EC253**	**3**	**0**	**3**

Pre-requisite, if any: Electronic Devices

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

CO1	Understand basic operation of various power semiconductor devices and passive components
CO2	Understand the basic principle of switching circuits.
CO3	Design AC/DC rectifier, DC/DC converter and DC/AC inverter circuits.
CO4	Understand the role power electronics play in the improvement of energy usage, efficiency and the development of renewable energy technologies.

Syllabus:

Introduction to power electronics; applications and role of power electronics.

Introduction to power semiconductor devices, operating characteristics of Power Diode, SCR, Power BJT, Power MOSFET and IGBT; Driver circuits and Snubber circuits.

Introduction to AC/DC rectifiers, principle of operation of phase controlled rectifiers, single phase and three phase AC-DC line commutated converters, dual converter, and introduction to unity power factor converters. Applications: DC motor drives and Battery chargers.

Introduction to DC/DC converters, Principle of operation of DC/DC (Buck, Boost, Buck-Boost, Cuk, Fly-back and Forward) converters. Applications: Power supply, DC motor drives and SMPS.

Introduction to DC/AC inverters, PWM techniques, Principle of operation of single phase and three phase DC-AC inverters, Applications: AC motor drives, UPS, active filters, CFL, renewable power generation, induction and dielectric heating.

Text Book(s):

1. N. Mohan, T. Undeland, and W. Robbins, “Power Electronics: Converters, Applications, and Design,” 3rd Edition, Wiley, 2003.
2. M. Rashid, “Power Electronics: Circuits, Devices & Applications,” Prentice Hall, 3rd Edition, 2003.

References & Web Resources:

1. J. P. Agrawal, “Power Electronic Systems: Theory and Design,” Pearson, 2013.
2. Batarseh, “Power Electronic Circuits,” John Wiley, 2004. 2. R. W. Erickson and D.Maksimovic , “Fundamentals of Power Electronics,” 2 nd Edition, Springer, 2001.
3. R. W. Erickson and D. Maksimovic , “Fundamentals of Power Electronics,” 2nd Edition, Springer, 2001.

Course Title	Course Code	Structure (I-P-C)		
Engineering Economics	**DS205**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Understand and coordinate his engineering acumen with economic aspects.
CO2	Take decisions independently on various aspects of an enterprise functioning.
CO3	Appraise economic influences on decision making.
CO4	Use accounting information for in the process of decision making.
CO5	Apply futuristic economic value in the decision making.

Syllabus:

Economics for Engineering: Understanding concepts with reference to engineering: economics Micro, macro, demand and supply, relationship with price, market structures, national income, per capita income, GDP, NDP, BOP, Fiscal (taxes) and monetary policies, banking: types of banks, significance of stages of business cycle to engineering.

Engineering Economic Decisions: Concepts and types of trade, business and industry – Types of organization of business – Economic decision-making process – Strategic economic decisions (case study) – Principles of economic decisions – Factors influencing decisions: Economic and non-economic.

Accounting for Engineers: Financial goals of business – Cash flows: inflow & outflow – Recurring & non-recurring – Revenues & Expenses – The income statement – Classification of assets & liabilities – Types of shares - The Balance sheet.

Understanding Financial Statements: Significance of Understanding financial statements from Engineering perspective - Ratios of Profitability, solvency, liquidity and wealth maximization, leverage and turnover. Earnings available to equity shares – Decision making based on understanding of financial statements.

Depreciation: Meaning – Reasons - Types – depreciation as non-cash expense – Depreciation as fund for investment - Methods: Straight line, diminishing balances and sinking fund – Decision making on the choice of methods.

Cost concepts and Behavior: Meaning of cost – Cost classification: Functional – Cost statement – Decision making using cost statement – Tenders - Fixed and variable costs – other classifications – Decision making using cost behavior: Marginal cost statement - BEP, graphical representation, MS, Profit statement, Sales for Desired profit – P/E ratio and its uses – Decision making using BEP.

Capital Budgeting: Significance of financial goals for engineers – concept of Budgeting – Meaning and significance of Capital budgeting decisions – Principles of investing - Traditional methods: payback period and Accounting Rate of Return – Rate of return analysis – Decision making using payback and ARR.

Present Worth Analysis: Methods of financing – concept of cost of capital – Overall cost of capital rate as discounting rate - Time value of money – Present worth analysis – Annual Equivalent Analysis - Decision making based on NPV and IRR. Evaluation of Social benefit and social cost projects –B-C Ratio.

Text Books and References:

1. Samuelson P A, Nordhans W D, “Economics”, McGraw Hill, 1995.

2. Chan S Park, “Contemporary Engineering Economics”, Prentice Hall, 2011.

3. John A. White, Kellie S. Grasman, Kenneth E. Case, Kim LaScola Needy, DavidB. Pratt, “Fundamentals of Engineering Economic Analysis”, First Edition, Wiley, 2014.

4. Blank Tarquin, “Engineering Economy”, 6th Edition. McGraw-Hill, 2005.

Course Title	Course Code	Structure (I-P-C)		
Probability Theory and Statistics	**DS204**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Solve problems on discrete and continuous random variables.
CO2	Identify the characteristics of different discrete and continuous distributions.
CO3	Analyze the statistical problems on large and small samples.
CO4	Apply the knowledge of probability and statistics in solving engineering problems.

Syllabus:

Introduction to Probability: Sets, Events, Axioms of Probability, Conditional Probability and Independence, Bayes Theorem.

Random Variables: Definitions, Cumulative Distribution Functions, Probability Mass Function, Probability Density Function, Joint and Conditional Distributions.

Expectations: Mean, Variance, Moments, Correlation, Chebychev and Schwarz Inequalities, Moment-Generating and Characteristic Functions, Chernoff Bounds, Conditional Expectations, Law of Large Numbers, Central Limit Theorem. Uniform, Binomial, Poisson and Normal Distributions.

Test for Large Samples: Testing of Hypothesis –Null and alternate hypothesis, level of significance and critical region-Z-test for single mean and difference of means, single proportion and difference of proportions.

Test for Small Samples: t-test for single mean and difference of means – F-test for comparison of variances, Chi-square test for goodness of fit, Chi-square test for independence.

Correlation and Regression: Correlation, lines of regression and examples.

Text Book(s):

1. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand & Co, 2006.
2. R. A. Johnson: Miller and Freund's Probability and Statistics for Engineers, Pearson Publishers, 9th Edition, 2017Thomas. G.B, and Finney R.L, Calculus, Pearson

Education, 2007.

References & Web Resources:

1. S. Milton and J. Arnold, Introduction to Probability and Statistics, Tata McGraw Hill Education Private Limited, 4th Edition, 2006.
2. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House. 2005.

Course Title	Course Code	Structure (I-P-C)		
Digital Signal Processing Practice	**EC254**	**0**	**3**	**2**

Pre-requisite, if any: Signals and Systems

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

CO1	Understand various properties of signals and systems
CO2	Apply various operations (filtering) on signals
CO3	Become aware of various applications of Signal Processing
CO4	Analyze DFT, DTFT, and FFT on discrete signals.

Syllabus:

Convolution, DFT, FFT, spectra analysis of a digital signal using DTFT, Sampling, quantization, reconstruction, companding, noise cancellation, FIR filter design, IIR filter design.

Text Book(s):

1. S. K. Mitra, "Digital Signal Processing: A Computer-Based Approach", Fourth edition, Tata Mcgraw Hill Publication, 2013.

2. E. Ifeachor, B. W. Jervis, "Digital Signal Processing: A Practical Approach" Second edition, Pearson, 2002.

References & Web Resources:

1. S. W. Smith, "Digital Signal Processing: A Practical Guide for Engineers and Scientists", 3rd Edition, Newnes (an imprint of Butterworth-Heinemann Ltd.), 2002.

2. Manuals of TI TMS320C67XX DSP Starter Kit.

3. A.V. Oppenheim, R.W. Schafer, and J. R. Buck, "Discrete-Time Signal Processing," Pearson Education, 3rd Edition, 2010.

Course Title	Course Code	Structure (I-P-C)		
Analog Circuits Practice	**EC255**	**0**	**3**	**2**

Pre-requisite, if any: Electronic Devices

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

CO1	Understand analog circuits.
CO2	Analyse and design of amplifiers viz. VCVS, VCCS, CCVS, CCCS. 3.
CO3	Analyse and design of analog circuits with operational amplifiers.
CO4	Analyse and design the analog filters

Syllabus:

Half wave and full wave rectifiers design
Diode based clipper and clamper circuits design
Voltage regulator design using Zener diode
RC Circuit Analysis
BJT voltage transfer characteristics analysis
Operation amplifier analysis
Circuits using Op-Amps, Filters, and Oscillators
Common emitter amplifier design
Analysis of common source characteristics of NMOS transistor
Basic NMOS common source audio amplifier design
Power Supply analysis

Text Book(s):

1. B. Razavi, “Fundamentals of Microelecronics,” Wiley Student Edition, 2010.

2. S. Franco, “Design with Operational Amplifiers and Analog Integrated Circuits,” McGraw-Hill Series in Electrical and Computer Engineering, 4th Edition, 2015.

References & Web Resources:

1. Sedra and Smith, “Microelectronic Circuits,” 7th Edition, Oxford University Press.

2. D. A. Newman, “Electronic circuits,” 4th Edition, TMH.

Course Title	Course Code	Structure (I-P-C)		
Electrical Drives Practice	**EC256**	**1**	**3**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engineering

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

CO1	Understand how power electronic converters and inverters operate.
CO2	Possess an understanding of feedback control theory.
CO3	Analyze and compare the performance of DC and AC machines.
CO4	Design control algorithms for electric drives which achieve the regulation of torque, speed, or position in the above machines.

Syllabus:

Experiments conducted in this course bring out the basic concepts of different types of electrical machines and their performance.

Experiments are conducted to introduce the concept of control of conventional electric motors such as DC motor, AC Induction motor and also special machines such as Stepper motor, Permanent magnet brushless motors, Servo motor.

Speed-Torque characteristics of various types of load and drive motors are also discussed.

The working principle of various power electronic converters is also studied by conducting experiments.

References & Web Resources:

1. R. Krishnan, “Electric Motor Drives: Modeling, Analysis, and Control,” Prentice Hall, 2001.

2. N. Mohan, “Electric Drives: An Integrative Approach,” MNPERE, 2001.

Third Year

Course Title	Course Code	Structure (I-P-C)		
Microprocessors and Microcontrollers	**EC301**	**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

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

CO1	Learn the functional behavior of a microprocessor using assembly instructions.
CO2	Learn to develop suitable computing architectures for certain applications
CO3	Use microprocessors and microcontrollers for building real time systems
CO4	Understand the architecture of microprocessor.

Syllabus:

Introduction to Computer Organization/Architecture, Need for Processors, Evolution of processors. (1 hour), Basic data path of the processor, Arithmetic Logic Unit Design (fixed/floating point adders, multipliers, dividers), Circuit pipelining

Harvard Versus Von-Neumann, RISC versus CISC, Register File, General Instruction Types, Addressing Modes, and instruction pipelining, Data Hazards, Control Hazards, Structural Hazards, Hazard Resolution Techniques, Instruction and data level parallelism, VLIW, Superscalar, SIMD processors.

Memory: Main memory Technologies (SRAM, DRAM), Cache memory organization, improving cache performance, cache coherence techniques, Virtual Memory Organization, Secondary storage devices,Control Unit: Hardwired Implementation and Micro programmed Control

Input/Output Unit: access of I/O devices, I/O ports, I/O control mechanisms – Program Controlled I/O. Interrupt controlled I/O and DMA controlled I/O; I/O interfaces – Serial port, parallel port, USB port, SCSI bus, PCI bus; I/O peripherals – Keyboard, display, secondary storage devices.8086 and ARM 7 architectures, addressing modes, instructions, and interfaces.

Text Book(s):

1. D. A. Patterson and J. L. Hennessy, Computer Organization and Design - ARM, Morgan Kaufmann, 2010..
2. J. Stokes, Inside The Machine: An Illustrated Introduction to Microprocessors and Computer Architecture, No Starch Press, Inc 2007, ISBN-13: 978-1-59327-104-6.

References & Web Resources:

1. S. Furber, ARM System-on-chip Architecture, 13th impression, Pearson, 2012.
2. B. B. Brey, Intel Microprocessors, 8th edition, Prentice Hall, 2008.

Course Title	Course Code	Structure (I-P-C)		
Analog and Digital Communication Techniques	**EC302**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems

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

CO1	Understand the Analog and Digital Communication Systems in detail with its concepts, techniques, and application usage
CO2	Learn GSM, CDMA, Wi-Fi and Bluetooth.
CO3	Perform various analog and digital modulations and demodulations.
CO4	Understand SNR calculations of various modulations.

Syllabus:

Communication Systems, Design Challenges: Channel Distortions and Noises, Message Sources, Channel Effect, Signal-To-Noise Ratio, Information Capacity, Modulation and Detection

Review of Probability Theory: random variables, pdf, cdf, marginalization, functions of random variables, MGF, CLT, random processes, correlation, Gaussian processes through LTI system.

Analog Communication: Band pass signal and system representation, AM: generation and demodulation, FM and PM: generation and demodulation, Matched filter, and correlation receiver, Super heterodyne receiver, Phase recovery with PLLs, PAM, PCM, Delta modulation.

Digital Communication: ASK, BPSK, M-PSK, QAM, FSK, MSK, - transmitter and receiver structures, BER Analysis, Bandwidth/Power efficiency, Carrier recovery – squaring and Costas loop, DPSK.

Text Book(s):

1 Simon Haykin, An Introduction to Analog and Digital Communications, wiley Vol 2, 2008.

2. B. P. Lathi and Z. Ding, “Modern Digital and Analog Communication Systems,” 4th Edition, Oxford University Press, 2011.

References & Web Resources:

1. John G Proakis, Digital Communications, 4th edition, 2008.

Course Title	Course Code	Structure (I-P-C)		
Control Systems	**EC303**	**3**	**0**	**3**

Pre-requisite, if any: signals and systems

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

CO1	Design controllers and analyse using classical tools
CO2	Understand impact of implementation issues (nonlinearity, delay)
CO3	Indicate the robustness of control design.
CO4	Linearize a nonlinear system, and analyse stability

Syllabus:

Scope of control, Parts of a control system, Multidisciplinary nature, Scope of present course. Mathematical modelling of physical systems: Differential equation, Transfer function, and Equivalence between the elements of different types of systems.

Linear systems and their s-domain representations: Linearity and linearization, Transfer function and its interpretation in terms of impulse and frequency responses, Block-diagram and signal flow graph manipulations

Characterization of systems: Stability -- concept and definition, poles, Routh array, internal stability of coupled systems, Time domain response and Frequency domain response; Link between time and frequency domain response features

Closed loop operation - Advantages: Sensitivity, Disturbance and noise reduction, Structured and unstructured plant uncertainties.Analysis of closed loop systems: Stability and relative stability using root-locus approach, Nyquist stability criterion, Steady state errors and system types.

Compensation techniques: Performance goals, specifications, PID, lag-lead and algebraic approaches for controller design.

State variable representations.

Text Book(s):

1. N. S. Nise, “Control Systems Engineering,” Wiley, 2014.Meriam
2. B.C. Kuo, “Automatic Control Systems”, 8th Edition, John Wiley.

References & Web Resources:

1. I. J. Nagrath and M. Gopal, “Control System Engineering,” New Age International publishers, 2008.

2. J. J. Distefano, A. R. Stubberud, and I. J. Williams, “Control Systems,” Shaum’s outline Series, 3rd Edition, McGraw Hill.

Course Title	Course Code	Structure (I-P-C)		
Transmission Lines, Waveguides, and Antennas	**EC304**	**3**	**0**	**3**

Pre-requisite, if any: Electromagnetics

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

CO1	Understand the high frequency circuit analysis.
CO2	Analyse the electromagnetic wave propagation through different structures
CO3	Design the EM radiating elements.
CO4	Implement the RF and microwave systems.

Syllabus:

Primary and secondary parameters, transmission line equations, Input impedance, standing wave ratio, power, Smith chart, impedance matching, impedance transformation.Vector algebra, coordinate systems, gradient of a scalar field, divergence of a vector field, divergence theorem, curl of a vector field, Stokes theorem.

Differential and integral forms and their interpretation, boundary conditions,wave equation, Poynting vector. reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth

Rectangular and circular waveguides, light propagation in optical fibers.Antenna working principle, antenna parameters, dipole and monopole antennas, linear antenna arrays

Text Book(s):

1. Matthew N.O. Sadiku (Author), S.V. Kulkarni, Principles of Electromagnetics, 6th Edition, Oxford, 2015.
2. W. H. Hayt and J. A. Buck, Engineering Electromagnetics, Tata McGraw Hill Education Pvt. Ltd, 2006.

Course Title	Course Code	Structure (I-P-C)		
Entrepreneurship and Management Functions	**DS301**	**2**	**0**	**2**

Pre-requisite, if any: Nil

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

CO1	Find units and dimensions of physical properties
CO2	Draw free body diagrams, study the dynamics of an object and predict the subsequent motion
CO3	Use polar coordinates to describe rotational motion of an object.
CO4	Understand the planetary motion and gravitation
CO5	Apply the concepts of angular momentum and torque for rigid body dynamics

Syllabus:

Introduction, Division of labor and creation of value, Evolution of organizations, industries and sectors, for profit and non-profit, Role of Entrepreneurs and Managers in value creation, Principles of Management - Planning, Organizing, Resourcing, Directing

Strategy & Planning, understanding industry dynamics & competition (Porter's Framework), Understanding the industry value chain and firm positioning

Resource Management, Financial management (Sources of funding, how to read a P&L, balance sheet), Human resource management (Interviewing, compensation, motivation), Global sourcing and supply chain management

Management Information & Decision Making, Legal and Regulatory environment.

Text Book(s):

1. Peter F Drucker, The Practice of Management, Harper Collins, 2006, ISBN: 978-006087897
2. Hentry Mintzberg, Managing, Berret-Koehler Publishers, 2009, ISBN: 978-1605098746

References & Web Resources:

1. Michael Porter, On competition: Updated and Expanded Edition, HBS, 2008, ISBN: 978-1422126967
2. Vasanta Desai, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, ISBN:9788183184113.

Course Title	Course Code	Structure (I-P-C)		
Micro Processors and Microcontrollers Practice	**EC305**	**0**	**3**	**2**

Pre-requisite, if any: Digital logic design

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

CO1	Program and use microprocessor 8086 for real time applications
CO2	Program and use ARM7 for real time application
CO3	use polar coordinates to describe rotational motion of an object.
CO4	understand the planetary motion and gravitation
CO5	apply the concepts of angular momentum and torque for rigid body dynamics

Syllabus:

8086 programming : Assembly code for simple addition, simple subtraction, simple multiplication, division, multiply accumulation, matrix addition/subtraction/multiplication, finding the odd-even, addition of N numbers, convolution, find the largest of N numbers, and so on. Accessing the peripherals (Switches, LEDs, Keypad, seven segment display, buzzer, relay, ADC, and temperature sensor) of 8086 development boards. Real time applications (traffic light control, stepper motor control, logic control, and so on) using 8086 and 8051 development boards.

ARM7 programming : Accessing the peripherals (Switches, LEDs, Keypad, seven segment display, buzzer, relay, ADC, and temperature sensor) of ARM7-LPC2148 development board, Assembly code for simple addition, simple subtraction, simple multiplication, division, multiply accumulation, matrix addition/subtraction/multiplication, finding the odd-even, addition of N numbers, convolution, find the largest of N numbers, and so on.

Project Work (Individual or 2-per group with respect to the availability of boards): Any project work using the programming skills obtained from the aforementioned topics with 8086 or ARM7 development boards. The title and objective of the projects will be chosen or formed by the students.

Text Book(s):

1. S. Furber, ARM System-on-chip Architecture, 13th impression, Pearson, 2012.

2. Kenneth J. Ayala, The 8086 Microprocessor: Programming and Interfacing The PC, Delmar Publishers, 2007

References & Web Resources:

1. A. K. Ray, K. M. Bhurchandi, Advanced Microprocessors and Peripherals, TMH, 2007.

Course Title	Course Code	Structure (I-P-C)		
Analog and Digital Communication Techniques Practice	**EC306**	**0**	**3**	**2**

Pre-requisite, if any: signals and systems

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

CO1	Program and use microprocessor 8086 for real time applications
CO2	Program and use ARM7 for real time application
CO3	use polar coordinates to describe rotational motion of an object.
CO4	understand the planetary motion and gravitation
CO5	apply the concepts of angular momentum and torque for rigid body dynamics

Syllabus:

Amplitude Modulation/Demodulation : DSB-FC, DSB-SC, SSB. Frequency Modulation/Demodulation, Phase Modulation/Demodulation. Delta modulation/Demodulation and PCM. BPSK, QPSK, PAM, MPSK, MQAM, FSK, modulation and demodulation/detection. FoM and PSD computations Spread Spectrum Implementation

Text Book(s):

1. B. P. Lathi and Z. Ding, “Modern Digital and Analog Communication Systems,” 4th Edition, Oxford University Press, 2011.

2. S. Haykin, “Communication Systems,” 4th Edition, Wiley, 2006

References & Web Resources:

1. J. M. Wozencraft and I. M. Jacobs, “Principles of Communication Engineering,” Wiley, 1965.

2. J. R. Barry, E. A. Lee, and D. G. Messerschmitt, “Digital Communication,” 3rd Edition, Springer, 2004. .

Course Title	Course Code	Structure (I-P-C)		
Transmission Lines, Waveguides, and Antennas Practice	**EC307**	**0**	**3**	**2**

Pre-requisite, if any: Electromagnetics

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

CO1	Perform various analog and digital modulations
CO2	Analyze S-parameters of RF and Microwave components
CO3	Transmit and receive EM signals. Design RF and Microwave circuits such as filters, Antennas, and so on
CO4	Understand the behaviour high frequency components.

Syllabus:

Non-Ideal Characteristics of lumped Elements: Study of non-ideal characteristics of Resistor, Capacitors and Inductors at high Frequencies using vector network Analyzer. S-parameter measurements of microwave components like Microstrip line, Filters, Power dividers, Couplers, Amplifiers, Mixer, and Oscillators.

Gunn Diode Characteristics, Klystron Characteristics, Frequency, Wavelength, Reflection Coefficient and VSWR measurement. Properties of Microwave components (Couplers, Magic Tee, Attenuator, Short Circuit, Open Circuit).

Radiation pattern of a Waveguide antennas. Design, Fabricate, and Measure any one RF and Microwave Component: Microstrip Antenna, Filter, Coupler, Amplifier, Mixer, and Oscillator.

Text Book(s):

1. Matthew N.O. Sadiku (Author), S.V. Kulkarni , Principles of Electromagnetics, 6th Edition, Oxford, 2015.

2. David M. Pozar, Microwave Engineering, 4th Edition, Wiley, 2013.

References & Web Resources:

1. Balanis, Antenna Theory: Analysis and Design, 3rd Edition, Wiley, 2009.

Course Title	Course Code	Structure (I-P-C)		
Sensing Instrumentation Practice	**EC308**	**1**	**3**	**3**

Pre-requisite, if any: Nil

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

CO1	Build systems which would sense the different physical signal
CO2	Process the signals in the required analog or digital formats
CO3	Calibrate sensors according the required applications.
CO4	Understand the characteristics of transducers.

Syllabus:

Transducers, transducer sensing and functions, Passive and active – Resistance, inductance and capacitance, Strain Gauges, Hall Effect sensors, Optical sensors.

Measurement of non-electrical quantities such as displacement, velocity, acceleration, pressure, force, flow and temperature, calibration of sensors, Data acquisition and detection techniques, Signal conversion, PC-based Instrumentation System.

Practice includes experiments from following topics:

Signal generation – Instrumentation amplifiers – Signal conversion and processing – Characteristics of Transducers - Calibration of sensors – Measurement of physical quantities.

Text Book(s):

1. Alan S. Morris, Measurement and Instrumentation Principles, Elsevier, 2001.

2. Sawhney. A. K, Course in Electrical & Electronics Measurement & Instrumentation, Dhanpat Rai, 2007.

References & Web Resources:

1. Howard Austerlitz, Data acquisition techniques using PCs, Academic Press, 2nd Ed. 2002.

2. Bruce Mihura, LabVIEW for Data Acquisition (National Instruments Virtual Instrumentation Series), Prentice Hall, 2001.

Course Title	Course Code	Structure (I-P-C)		
VLSI System Design	**EC351**	**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

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

CO1	Design the digital systems using Verilog or VHDL
CO2	Estimate the circuit/system performance, area, and power dissipation
CO3	Implement the low power and high throughput techniques on digital VLSI circuits.
CO4	Develop the Custom IPs to integrate into Digital Systems using EDA..

Syllabus:

Introduction to VLSI Design, Need for VLSI Design, Various VLSI design flows, Basic classifications of VLSI design. Digital Arithmetic Circuits, Fixed Point/Floating Point/Galois Field Arithmetic, RTL Design using Verilog HDL. Introduction to Hardware-Software Co-design, Custom IPs, High level synthesis, and formal hardware verification.

MOS Transistors, Operation of MOSFET, CMOS Logic - Inverter, Logic Gates, Pass Transistors and Transmission Gates, Tri states, Multiplexers, Sequential Circuits, and Pass Transistor Logic . CMOS Fabrication and Layout - Inverter Cross-section, Fabrication process, Layout Design Rules, Gate Layouts, Stick Diagrams. Timing optimization, Transient response, RC Delay Model, Linear Delay Model, Logical Effort of Paths. Statistical timing analysis.

Sources of Power Dissipation, Dynamic Power, Static Power, Energy-Delay Optimization, Low Power Architectures.Testers, text fixtures, and Test Programs, BIST, Scan Chains, Design for Testability, Fault tolerant designs. CMOS chip design options: Full custom ASICs, Std. Cell based ASICs, Gate Array based ASICs, Programmable logic structures-PLA, PAL, PROM, FPGA. Introduction to Physical Design: Floor plan, power plan, placement, routing, physical verification.

Text Book(s):

1. Weste and Eshraghian: Principles of CMOS VLSI design, Addison Wesley, 4th Edn, 2011.

2. Samir Palnitkar: Verilog HDL - Guide to Digital design and synthesis, Pearson Education, 3rd Edn, 2003

References & Web Resources:

1. CMOS Logic Circuit Design, John P Uyemura, 2009, Springer

2. Verilog for Digital Design, Frank Vahid, Roman Lysecky, Wiely, 2007

Course Title	Course Code	Structure (I-P-C)		
Wireless Communication	**EC352**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Sysetms, Analog and Digital Communication Techniques

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

CO1	Understanding of Wireless Communication system in detail with its concepts, techniques and application usage.
CO2	This course included basics of Wireless transmission, Channel Modelling, Capacity and Fading.
CO3	This course also provides the Multiple Access Techniques: Multicarrier Modulation techniques and MIMO techniques along with overview of future communication techniques like 4G and 5G
CO4	Every topic is to be explained with its function either with demonstration and/or simulation using suitable software.

Syllabus:

Introduction: Wireless Communication Overview, Wireless Spectrum, IEEE Wireless standards, Wireless Transmission, Gaussian random variables, review of digital modulation and its performance, Multiple access techniques TDMA,CDMA, FDMA and SDMA.

The Wireless Channel: Fading, Large scale fading, small scale fading, Physical modelling for wireless channels, different statistical channel models. Channel parameters: Time and Frequency coherence, delay spread, power profile, Capacity of wireless Channel- Capacity of Flat Fading Channel, Channel State Information, Capacity with Receiver diversity – Capacity comparisons – Capacity of Frequency Selective Fading channels, Jakes model for wireless channel correlation.

Code Division for Multiple Access (CDMA): Introduction to Spread Spectrum, DSSS, FHSS, CDMA, Block diagram, fundamental of CDMA codes, Multi-user CDMA, advantages of CDMA, the Near-Far problem, performance of CDMA (uplink and down-link) with Multiple Users, Asynchronous CDMA. Multicarrier Modulation: Data Transmission using Multiple Carriers, Overlapping Sub channels, Mitigation of Sub Carrier Fading, Orthogonal Frequency Division Multiplexing (OFDM), Cyclic Prefix, Matrix Representation of OFDM, Vector Coding, PAR, Frequency and Timing Offset, Multi-user Channels, Multiple Access, Downlink Channel Capacity, Uplink Channel Capacity, Capacity in AWGN, SC-FDMA.

Multiple-Input-Multiple-Output Wireless Communications: Introduction to MIMO wireless communication, MIMO system model, MIMO channel estimation. MIMO receivers: Zero Forcing, MMSE, Sphere decoding, Successive Interference Cancellation (SIC) (Non-linear receiver). Singular value decomposition (SVD) of MIMO channel and MIMO capacity. MIMO Techniques: Space-time block codes (STBC), Spatial Multiplexing (SMX), Vertical

Bell Labs Layered Space time (VBLAST), Spatial Modulation (SM), Generalized Spatial Modulation (GSM), Generalized Space Shift Keying (GSSK), MIMO-OFDM, Massive MIMO.

Overview of Existing and Future Wireless Systems: 1G Wireless – AMPS, 2G Wireless - GSM, CDMA, CDPD, 2.5 Wireless:HSCSD, GPRS, EDGE, 3 G Wireless -WCDMA, CDMA2000, WiMAX, HSPA, HSDPA, 4G, LTE, 5G.

Text Book(s):

1. Andrea Goldsmith, Wireless Communication, Cambridge University Press.

2. Aditya Jagannatham, Principles of Modern Wireless Communication Systems, McGraw Hill, (2016)

References & Web Resources:

1. Theodore Rappaport, Wireless Communications, principles and Practices, 2nd Edition, Pearson.163

Course Title	Course Code	Structure (I-P-C)		
Information Theory and Coding	**EC353**	**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

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

CO1	Analyze different sources in terms of entropy.
CO2	Analyze different channels in terms of mutual information.
CO3	Design data compression for various sources.
CO4	Compute the capacity of different channels.

Syllabus:

Information - Fundamentals: Entropy, joint entropy and conditional entropy, relative entropy and mutual information, chain rules for entropy, relative entropy, and mutual information, Jensen's inequality, log sum inequality, sufficient statistics, Fano's inequality.

Asymptotic Equipartition Property (AEP): AEP, consequence of AEP - data compression, typical set.

Data Compression: Kraft inequality, optimal codes and bounds on optimal codelength, Kraft inequality for uniquely decodable codes, Run length codes, Huffman codes, Shannon-Fano-Elias coding.
Channel Capacity: (Binary) Symmetric Channels, Jointy typical sequences, the channel coding theorem, Fano's inequality and the converse to the coding theorem,

Error Control Coding: Hamming codes, CRC, joint source-channel coding theorem, linear block codes, cyclic codes, convolutional codes.

Gaussian Channel: Differential entropy, coding theorem for Gaussian channels (5 hours)

Text Book(s):

1. T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, John-Wiley & Sons, 2006. ISBN: 978-0471241959

2. I. Csiszar and J. Korner, Information Theory: Coding Theorems for Discrete Memoryless Systems, 1st edition, Akademiai Kiado, 1997. ISBN: 978-9630574402

References & Web Resources:

1. R. G. Gallager, Information Theory and Reliable Communication, 1st edition, Wiley, 1968, ISBN: 978-0471290483

Course Title	Course Code	Structure (I-P-C)		
Embedded Systems Practice	**EC354**	**1**	**3**	**3**

Pre-requisite, if any: Digital Logic Design

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

CO1	Understand how embedded systems interfaces operate (GPIO, interrupts, ADC/ DAC, etc.) using the ARM Cortex Launch Pad IDE and booster packs.
CO2	Perform experiments in sound, video (gaming) and mobile robots, with LCD displays, stepper and DC motors and RC servos.
CO3	Rapid prototype embedded systems using open source microcontrollers (such as Arduino, Raspberry Pi, Beagle Bone Black, and Intel Edison/Galileo).
CO4	Build wireless networked embedded systems using Arduino shields and modules (e.g., GPS, GSM/GPRS, Bluetooth, RFID, and ZigBee).

Syllabus:

Experiments in GPIO, serial interfacing, timer interrupts, data acquisition with ADC, sound and video, DAC.

Experiments in control of RC servos, stepper motors, DC motors, and design of video games and mobile robots.

Data acquisition and real-time control with Arduino, Raspberry Pi, and Beagle Bone Black microcontrollers, shields, and add-on boards. Experiments in wireless networked systems, using shields and modules, for GPS, GSM/GPRS, Zig Bee, Bluetooth, and RFID.

Experiments in IOT for smart automation, with Intel and Microsoft development kits.

Experiments with various bus interconnects such as I2C, UART, SPI, and so on.

Experiments using RTOS concepts such as multi-task application with various priority, MUTEX using using Semaphore, inter-task communication using FIFO, MBOX, and so on.

Text Book(s):

1. Jonathan Valvano and Ramesh Yerraballi, 2014, “Embedded Systems – Shape the World” (ebook).

2. J. W. Valavano, Embedded Systems: Introduction to Arm Cortex-M Microcontrollers, 2nd edition, Create Space, 2012. ISBN: 978-1477508992.

References & Web Resources:

1. J. W. Valavano, Embedded Systems: Real-Time Operating Systems for Arm Cortex M.

2. Microcontrollers, 2nd edition, Create Space, 2012. ISBN: 978-1466468863.

Course Title	Course Code	Structure (I-P-C)		
Electronic Manufacturing and Prototyping	**EC355**	**1**	**3**	**3**

Pre-requisite, if any:

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

CO1	Design optimized layout for printed circuits boards and multi-layer PCBs.
CO2	Design and development of PCBs using different simulator tools and prototyping.
CO3	Understand the manufacturing process of PCBs.
CO4	Debugging errors in PCB prototype.

Syllabus:

Overview of electronic systems manufacturing and packaging, Introduction to IC manufacturing and realization of passive components in ICs and VLSI, Surface Mount Technology, Thermal budget and Current trends.

An overview on CAD based manufacturing process of PCB, Industry standards for design, Mechanical and Electrical aspects of PCB design, Design for manufacturability, Design consideration for special circuits, PCB design flow- Schematic -layout - PCB design using created library -PCB printing using PCB prototyping machine-Testing and debugging of PCB.

Experiments - Design and development of PCBs using different simulator tools and prototyping.

Text Book(s):

1. R. T. Rao, Fundamentals of Microsystems Packaging, McGraw Hill, 2001, ISBN-10: 0071371699, ISBN-13: 978-0071371698.

2. J. Axelson, Making Printed Circuit Boards, TAB/McGraw Hill, 1993, ISBN- 10: 0070027994, ISBN-13: 978-0070027992.

References & Web Resources:

1. R. K. Ulrich, W. D. Brown, Advanced Electronic Packaging, : IEEE Press Series on Microelectronic Systems, 2 nd edition, 2006, Wiley-IEEE Press; ISBN-10: 0471754501, ISBN-13: 978-0471754503.

2. J. Varteresian, Fabricating Printed Circuit Boards (Demystifying Technology) 1st edition, Newnes, 2002. ISBN-10: 1878707507, ISBN-13: 978-1878707505.

3. R. A. Reis, Electronic project design and fabrication, 6th edition, Prentice Hall, 2004, ISBN-10: 0131130544, ISBN-13: 978-0131130548.

Course Title	Course Code	Structure (I-P-C)		
VLSI System Design Practice	**EC356**	**0**	**3**	**2**

Pre-requisite, if any: Digital Logic Circuits

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

CO1	Design the digital systems using Verilog or VHDL.
CO2	Estimate the circuit/system performance, area, and power dissipation.
CO3	Implement the low power and high throughput techniques on digital VLSI circuits
CO4	Develop the Custom IPs to integrate into Digital Systems using EDA.

Syllabus:

Introduction to RTL Design: Basic combinational (half adder, full adder, multiplexer, decoder, and so on) and sequential circuits design (Flip-flops and counters) using Verilog HDL with Xilinx Vivado or iverilog open source compiler with gtk waveform generator.

Familiarity of Arithmetic Circuits: 32-bit Ripple carry adder, recursive doubling based carry look ahead adder, Braun multiplier, Wallace tree multiplier, non restoring based division, IEEE-754 floating point adder/Subtractor/multiplier/divider, CORDIC.

Advanced VLSI circuit design concepts: Pipelining, clock gating to reduce the switching power dissipation, hardware reuse strategy (folded hardware) to reduce the area, fault tolerant digital circuit design, formal hardware verification using equivalence check, high level synthesis with Xilinx Vivado HLS, and performance analysis of RTL design & high level synthesis based digital system using Xilinx Vivado.

Hardware-Software Co-design: Design flow of hardware-software co-design using ZYNQ7000 board with Xilinx Vivado, Custom IP design (arithmetic circuits as mentioned above), hardware-software partitioning, and performance analysis of various hardware-software co-design techniques.

Project Work (Individual): Basic 32-bit Processor Design (Harvard Architecture with Microprogramming based Controller) that includes the functional units such as logic unit, fixed/floating point adder, multiplier, and divider. Here, two separate memories are used for data and instruction.

Text Book(s):

1. Weste and Eshraghian: Principles of CMOS VLSI design, Addison Wesley, 4th Edn, 2011.

2. Samir Palnitkar: Verilog HDL - Guide to Digital design and synthesis, Pearson Education, 3rd Edn, 2003.

References & Web Resources:

1. CMOS Digital Integrated Circuits Analysis, Sung-Mo (Steve) Kang, 2011, TMH

2. Introduction to VLSI Systems: A Logic, Circuit, and System Perspective, Ming Lo Bin, 2011, CRC Press, ISBN 9781439868591

3. CMOS Logic Circuit Design, John P Uyemura, 2009, Springer

4. Verilog for Digital Design, Frank Vahid, Roman Lysecky, Wiely, 2007

5. Digital VLSI Design with Verilog, A Textbook from Silicon Valley Polytechnic Institute, Williams, John Michael, 2014 Springer

6. Digital Design and Verilog HDL fundamentals, Joseph Cavanagh, 2007, CRC Press, ISBN9781420074154

Fourth Year

Course Title	Course Code	Structure (I-P-C)		
Mechanical Design for Electronic Systems	**EC402**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Perform the mechanical design of electronic systems including packaging, managing thermal stress and heat dissipation

Syllabus:

Thermodynamics in electronics - System & control volume - State & process - Forms of work, heat and interaction - Thermodynamic laws and equilibrium - Enthalpy and Entropy – Cyclic & non-cyclic process – Concept of total energy – Derivation of general energy equation for control volumes – Steady & unsteady flow process – Thermal efficiency and COP – Irreversible process.

Fluid Mechanics: The concept of a fluid – Themophysical properties of fluids - Properties of velocity field - Bernoulli's Equation – Laminar and Turbulent flows – Fluid friction and Boundary layers - Flow in plates, across bodies , inside channels - Effect of roughness.

Heat transfer: Conduction heat transfer – General conduction equation –One dimensional steady state conduction – Fins and extended surfaces – Contact resistance - Transient conduction of lumped and distributed systems – Convective heat transfer – Dimensionless group for convection – Forced convection – Elements of free convection – Elements of radiation heat transfer.

Importance of thermal and fluid management in electronics – Resistance heating in electronics - Heat generation in printed circuit boards – Estimation of Cooling loads in devices and power transmission mediums – Thermal resistance concepts – - Estimation of Junction temperature – Heat frames - Thermal conduction modules - Air and liquid cooled heat sinks – Thermoelectric power generation and refrigeration – Dielectric heating – Heat pipes and vortex tubes and their applications in electronic cooling - cooling fans - thermal stresses in electronics

Text Book(s):

1. Nag. P.K, Engineering Thermodynamics, Tata McGraw Hill, 2005.

2. Jones. J.B and Shapiro. H.N, Fundamentals of Engineering Thermodynamics, John Wiley, 1999..

References & Web Resources:

1. Moran. M.J. and Shapiro. H.N, Fundamentals of Engineering Thermodynamics, John Wiley, 2003.

2. Sonnag. R.E, Borgnakke. C and Van Wyan. G.J, Fundamentals of Thermodynamics, 6 Edn, John Wiley, 2003.

3. Spalding. D. B. and Cole. E.H, Engineering Thermodynamics, Edward Arnold, 1976.

Electives

Course Title	Course Code	Structure (I-P-C)		
Antenna Design	**EC361**	**3**	**0**	**3**

Pre-requisite, if any: Engineering Electromagnetics

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

CO1	Analyse a given Antenna
CO2	Measure a given Antenna
CO3	Design standard antennas
CO4	Develop new antenna structures with desired specifications

Syllabus:

Fundamental Concepts: Physical concept of radiation, Radiation pattern, near-and far-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency, Friis transmission equation, radiation integrals and auxiliary potential functions.

Radiation from Wires and Loops: Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.

Aperture and Reflector Antennas: Huygens' principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, Radiation from sectoral and pyramidal horns, design concepts, parabolic reflector and cassegrain antennas.

Broadband Antennas: Log-periodic and Yagi antennas, frequency independent antennas, Helical and Biconical antenna broadcast antennas, Spiral antenna.

Microstrip Antennas: Radiation mechanism, parameters and applications of microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas. Impedance matching of microstrip antenna.

Antenna systems and measurements: Receiving properties of antenna, Antenna noise and temperature, Gain measurement, polarization measurement, field intensity measurement, Antenna range Introduction and concept of antenna arrays. Case study on practical microstrip patch antenna for personal wireless communications consistent with the frequencies assigned by FCC.

Text Book(s):

1. C. A. Balanis, "Antenna Theory and Design", 3rd Ed., John Wiley & Sons., 2005.

2. W. L. Stutzman, and G. A. Thiele, "Antenna Theory and Design", 2nd Ed., John Wiley & Sons., 1998.

References & Web Resources:

1. R. E. Collin, "Antennas and Radio Wave Propagation", McGraw-Hill., 1985.
2. F. B. Gross, "Smart Antennas for Wireless Communications", McGraw-Hill., 2005
3. R. S. Elliot, "Antenna Theory and Design", Revised edition, Wiley-IEEE Press., 2003
4. J. D. Kraus and R. J. Marhefka, “Antennas for All Applications,” Third Edition, 2002.
5. S. R. Saunders, “Antennas and Propagation for Wireless Communication Systems,” John Wiley & Sons, 1999.

Course Title	Course Code	Structure (I-P-C)		
Numerical Techniques in Electromagnetics	**EC362**	**3**	**0**	**3**

Pre-requisite, if any: Engineering Electromagnetics

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

CO1	Understand various computational techniques and their pros and cons.
CO2	Understand which software works best in terms of speed, and accuracy for analysing a given structure
CO3	Develop codes to analyze the EM structures.
CO4	Develop EM simulation software tools

Syllabus:

Review of vector calculus, Overview of computational electromagnetics, Review of Maxwell's equations.
Analytical techniques in Electromagnetics.
Finite Difference Time Domain methods: Analysis, convergence, accuracy and numerical dispersion,incorporating dielectric and dispersive materials, absorbing boundary conditions, perfectly matched layers (PML), sources.

Moment Methods: Integral equations (EFIE,MFIE), Green's Functions, MOM.

Finite element methods: Formulation and Absorbing boundary conditions (FEM).

Applications of computational electromagnetics: Specific Absorption Rate, Radar RCS, Periodic structures, Eddy current calculations, capacitance and inductance calculations, Microwave inverse imaging, Antenna radiation problems, Calculating the modes of a waveguide structure using the integral equation method.

Text Book(s):

1. Numerical Techniques in Electromagnetics, Second Edition Hardcover – Import, 12 July 2000, by Matthew N.O. Sadiku
2. Analytical and Computational Methods in Electromagnetics, Artech House Electromagnetic Analysis, 30 September 2008, by Ramesh Garg, Raj Mittra

References & Web Resources:

1. Computational Electromagnetics for RF and Microwave Engineering, 28 October 2010, by David B. Davidson
2. Advanced Engineering Electromagnetics Paperback - 8 October 2008, by Constantine A. Balanis
3. Computational Methods for Electromagnetics: 4 (IEEE Press Series on Electromagnetic Wave Theory) Hardcover – Import, 12 December 1997, by Andrew F. Peterson, Scott L. Ray, Raj Mittra

Course Title	Course Code	Structure (I-P-C)		
RF and Microwave Integrated Circuits	**EC363**	**3**	**0**	**3**

Pre-requisite, if any: Engineering Electromagnetics

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

CO1	Analyse high frequency filters, couplers, amplifier, oscillators and mixer circuits.
CO2	Design high frequency filters, couplers, amplifiers.
CO3	Develop RFICs.
CO4	Develop MMICs.

Syllabus:

Electromagnetic Theory Review: Maxwell's Equations, Fields in Media and Boundary Conditions, The Wave Equation, General Plane Wave Solutions, Energy and Power, Transmission lines and waveguide solutions.

Transmission Line Theory: The Lumped-Element Circuit Model for a Transmission Line, Field Analysis of Transmission Lines, The Terminated Lossless Transmission Line, The Smith Chart, The Quarter-Wave Transformer, Generator and Load Mismatches, Lossy Transmission Lines, Transients on Transmission Lines.

Microwave Network Analysis: Impedance and Equivalent Voltages and Currents, Impedance and Admittance Matrices, The Scattering Matrix, The Transmission (ABCD) Matrix.

Impedance matching and tuning, Microwave filter design.

Noise and nonlinear distortion, active rf and microwave devices.

Microwave Power Amplifier, Low Noise Amplifier, Oscillator and Mixer Design.

Introduction to microwave systems.

Text Book(s):

1. David M Pozar, Microwave Engineering, 4th Edition, Wiley, 2013.

References & Web Resources:

1. Robert E Collin, Foundations for Microwave Engineering, 2nd Edition, Wiley, 2007.

2. Behzad Razavi, RF Microelectronics, 2nd Edition, Pearson, 2011.

3. I.D. Robertson , S. Lucyszyn, RFIC and MMIC Design and Technology: 13 (Materials, Circuits and Devices), Institution of Engineering and Technology, 2001.

Course Title	Course Code	Structure (I-P-C)		
Electromagnetic Interference and Compatibility	**EC364**	**3**	**0**	**3**

Pre-requisite, if any: Engineering Electromagnetics

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

CO1	Gain knowledge to understand the concept of EMI / EMC related to product design.
CO2	Diagnose and solve various electromagnetic compatibility problems.
CO3	Understand the sources of EMI and various coupling methods.
CO4	Learn the various method of doing the pre compliance measurement techniques.

Syllabus:

Introduction to EMI and EMC: Various EMC requirements and standards-Need for EMC and its importance in electronic product design - sources of EMI - few case studies on EMC.

Conducted and radiated emission: power supply line filters-common mode and differential mode current-common mode choke- switched mode power supplies.

Shielding techniques: shielding effectiveness-shield behavior for electric and magnetic field - aperture-seams-conductive gaskets- conductive coatings.

Grounding techniques: signal ground-single point and multi point grounding-system ground common impedance coupling -common mode choke-Digital circuit power distribution and grounding.

Contact protection: arc and glow discharge-contact protection network for inductive loads-C, RC, RCD protection circuit- inductive kick back.

RF and transient immunity: transient protection network- RFI mitigation filter-power line disturbance- ESD- human body model- ESD protection in system design.

PCB design for EMC compliance: PCB layout and stack up- multi layer PCB objectives Return path discontinuities-mixed signal PCB layout.

EMC pre compliance measurement: conducted and radiated emission test-LISN- Anechoic chamber.

Text Book(s):

1. H. W. Ott, Electromagnetic Compatibility Engineering, 2nd edition, John Wiley & Sons, 2011, ISBN: 9781118210659.

2. C. R. Paul, Introduction to Electromagnetic Compatibility, 2nd edition, Wiley India, 2010, ISBN: 9788126528752.

References & Web Resources:

1. K. L. Kaiser, Electromagnetic Compatibility Handbook, 1st edition, CRC Press, 2005. ISBN: 9780849320873.

Course Title	Course Code	Structure (I-P-C)		
Analog and Mixed Signal Circuit Design	**EC365**	**3**	**0**	**3**

Pre-requisite, if any: Analog Circuits

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

CO1	Design and analyze complex analog integrated circuits using industry level analog IC Design tools
CO2	Design and analyze ADC and DAC using EDA tools
CO3	Design and analyze various MOSFET based arithmetic circuits.
CO4	Learn the various method of power optimization in analog circuits.

Syllabus:

Introduction: Review of single state MOS amplifiers, current mirrors, cascode current mirrors, active current mirrors, biasing techniques.

Op-amp design: Differential pair with current mirror load, single stage op-amp characteristics, single stage op-amo tradeoffs, telescopic cascode op-amp, folded cascode op-amp, two stage op-amp, fully differential single stage op-amp.

Data converter fundamentals: Analog versus digital (or discrete time) signals, converting analog signals to data signals, sample and hold circuits, sample and hold characteristics, switched capacitor circuits, DAC specifications, ADC specifications.

Data converters: DAC architectures – digital input code, R-2R ladder networks, current steering, charge scaling DACs, cyclic DAC, pipeline DAC, ADC architectures – flash ADC, 2-step flash ADC, pipeline ADC, integrating ADC, successive approximation ADC.

Phase locked loop: simple PLL, frequency/phase detectors, charge pump PLL, application as frequency multiplier.

Text Book(s):

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016.
2. Baker, R. Jacob, CMOS: Circuit design, Layout, and Simulation. John Wiley & Sons, 2019.

References & Web Resources:

1. Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
2. Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
3. P. R. Gray, P. J. Hurst, S. H. Lewis and R. G. Meyer, Analysis And Design Of Analog Integrated Circuits, 5th edition, John Wiley & Sons, Inc., 2009.

Course Title	Course Code	Structure (I-P-C)		
Testing and Testability	**EC366**	**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

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

CO1	Identify the significance of testable design
CO2	Understand the concept of yield and identify the parameters influencing the same
CO3	Specify fabrication defects, errors and faults.
CO4	Implement combinational and sequential circuit test generation algorithms
CO5	Identify techniques to improve fault coverage

Syllabus:

Role of testing in VLSI Design flow, Testing at different levels of abstraction, Fault error, defect, diagnosis, yield, Types of testing, Rule of Ten, Defects in VLSI chip. Modelling basic concepts, Functional modelling at logic level and register level, structure models, logic simulation, delay models.

Various types of faults, Fault equivalence and Fault dominance in combinational sequential circuits. Fault simulation applications, General fault simulation algorithms- Serial, and parallel, Deductive fault simulation algorithms. Combinational circuit test generation, Structural Vs Functional test, ATPG, Path sensitization methods.

Difference between combinational and sequential circuit testing, five and eight valued algebra, and Scan chain based testing method. D-algorithm procedure, Problems, PODEM Algorithm, Problems on PODEM Algorithm. FAN Algorithm, Problems on FAN algorithm, Comparison of D, FAN and PODEM Algorithms. Design for Testability, Ad-hoc design, Generic scan based design.

Classical scan based design, System level DFT approaches, Test pattern generation for BIST, and Circular BIST, BIST Architectures, and Testable memory design-Test algorithms-Test generation for Embedded RAMs.

Fault Diagnosis Logic Level Diagnosis - Diagnosis by UUT reduction - Fault Diagnosis for Combinational Circuits - Self-checking design - System Level Diagnosis.

Text Book(s):

1. M. Abramovici, M. Breuer, and A. Friedman, “Digital Systems Testing and Testable Design, IEEE Press, 1990

2. Stroud, “A Designer’s Guide to Built-in Self-Test”, Kluwer Academic Publishers, 2002

References & Web Resources:

1. M. Bushnell and V. Agrawal, “Essentials of Electronic Testing for Digital, Memory & Mixed-Signal VLSI Circuits”, Kluwer Academic Publishers, 2000
2. V. Agrawal and S.C. Seth, Test Generation for VLSI Chips, Computer Society Press.1989.
3. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House.
4. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers.
5. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002.
6. A.L. Crouch, "Design Test for Digital IC's and Embedded Core Systems", Prentice Hall International.

Course Title	Course Code	Structure (I-P-C)		
Reliable Digital Communication System Design	**EC371**	**3**	**0**	**3**

Pre-requisite, if any: Communication Systems, Digital Logic Design

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

CO1	Learn the functional behaviour of various cryptography, intrusion detection, and error correction algorithms.
CO2	Learn to develop hardware architectures of various cryptography, intrusion detection, and error correction algorithms.
CO3	Develop the countermeasure prototypes of adversary attacks
CO4	Develop the crypto co-processors using FPGA.

Syllabus:

Information theory, Entropy, Properties of Entropy

Goals of Relilable Digital Communication: first level of defense (integrity, confidentiality, authenticity, and availability) and second level of defense (resilience to attacks).

Galois Field Arithmetic: Introduction to Group, Ring, and Fields, Prime/Polynomial field representation, Irreducible polynomial, primitive polynomial, minimal polynomial, Galois field addition, LSB first/MSB first/Montgomery Galois field multiplication architectures-bit serial, bit parallel, digit serial, systolic, and scalable architectures, Modular exponentiators-Square-multiply algorithm and Montgomery Ladder algorithm, Extended Euclidean algorithm/Fermat's little theorem based multiplicative inverse architectures.

Symmetric Encryption/Decryption Architectures: DES, 3-DES, and AES (fully folded, parameterized parallel, and fully parallel architectures).

Asymmetric Encryption/Decryption Architectures: ECC (right-to-left, left-to-right, Montgomery based scalar multiplication in affine/projective co-ordinates) and RSA.

HASH architectures: SHA512 and SHA3.

Key exchange protocols: Diffie Helmen, Elgamal, Neuro crypto key exchange protocol.

Authentication schemes: Yang Shieh and Eiji Okamato.

Pseudo random number generators, Stream ciphers.

Physical unclonable functions: RO PUF, larger decoder memory based PUF, and XOR PUF.

Intrusion Detection: Universal HASH functions, Cuckoo hashing, and Bloom filter.

Error detection codes: CRC, LRC, and parity check, Error correction codes-Hamming, BCH, Reed Solomon, LDPC, Convolutional, Turbo product, and concatenated codes, Hardware/software co-design analogous between ASIC/FPGA/hardware-software co-designs, need for crypto accelerators (or coprocessors), and hardware/software partitioning based AES/ECC architectures.

Side channel analysis: Power attack, Bit masking, and Cache template attack.

Text Book(s):

1. Doug R. Stinson , Cryptography Theory and Practice, Third Edition, CRC Press, 2006.

2. Shu Lin and Daniel J Castello, Error Control Coding, Second Edition, Printice Hall, 2004.

3. Haykin, An Introduction to Analog and Digital Communications, wiley Vol

2, 2008.

References & Web Resources:

1. A. J. Menezes, P. C. van Oorshot, and S. A. Vanstone, Handbook of Applied Cryptography, CRC Press, 1996.
2. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press, 2015.
3. Debdeep Mukhopadhyay and Rajat Subhra Chakraborty, Hardware Security: Design, Threats and Safeguards, CRC Press, 2014.

Course Title	Course Code	Structure (I-P-C)		
Satellite Communication	**EC372**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

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

CO1	Understand the satellite communication.
CO2	Understand the rrbits and space of satellite communication.
CO3	Understand the optical communication.
CO4	Develop the packet switched networks.

Syllabus:

OVERVIEW OF SATELLITE SYSTEMS, ORBITS AND LAUNCHING METHODS: Introduction, Frequency Allocations for Satellite Services, Intelsat, U. S. Domsats Polar Orbiting Satellites, Problems, Kepler's First Law, Kepler's Second Law, Kepler's Third Law, Definitions of Terms for Earth-orbiting Satellites, Orbital Elements, Apogee and Perigee Heights, Orbital Perturbations, Effects of a Non-spherical Earth, Atmospheric Drag, Inclined Orbits, Calendars, Universal Time, Julian Dates, Sidereal Time, The Orbital Plane, The Geocentric, Equatorial Coordinate System, Earth Station Referred to the IJK Frame, The Top centric-Horizon Co-ordinate System, The Sub-satellite Point, Predicting Satellite Position.

GEOSTATIONARY ORBIT & SPACE SEGMENT: Introduction, Antenna Look Angels, The Polar Mount Antenna , Limits of Visibility , Near Geostationary Orbits, Earth Eclipse of Satellite, Sun Transit Outage, Launching Orbits, Problems, Power Supply, Attitude Control, Spinning Satellite Stabilization, Momentum Wheel Stabilization, Station Keeping, Thermal Control, TT&C Subsystem , Transponders, Wideband Receiver, Input De-multiplexer, Power Amplifier, Antenna Subsystem, Morelos, Anik-E, Advanced Tiros-N Spacecraft.

OPTICAL NETWORK ARCHITECTURES: Introduction to Optical Networks; Layered Architecture- Spectrum partitioning, Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays, Connection Management and Control; Static and Wavelength Routed Networks; Linear Light wave networks; Logically Routed Networks; Traffic Grooming; The Optical Control Plane- Architecture, Interfaces, Functions; Generalized Multiprotocol Label Switching – MPLS network and protocol stack, Link management, Routing and Signaling in GMPLS.

OPTICAL PACKET SWITCHED NETWORKS: Network Architectures- Unbuffered Networks, Buffering Strategies; OPS enabling technologies, Test beds; Optical Burst Switching, Switching protocols, Contention Resolution, Optical Label Switching, OLS network test beds, Control and Management – Network management functions, Configuration management, Performance management, Fault management, Optical safety,

Service interface; network Survivability- Protection in SONET / SDH and IP Networks, Optical layer Protection, Interworking between layers.

FREE SPACE OPTICAL COMMUNICATION: Analog and digital FSOC data link, atmospheric attenuation, scattering, scintillation index, beam wandering, beam wave front aberration, adaptive optics, active optics, deformable mirror control, RoFSO, atmospheric channel models, estimation of refractive index, modulation and demodulation techniques, error control techniques.

Text Book(s):

1. Satellite Communications, Dennis Roddy, McGraw-Hill Publication Third edition2001
2. Satellite Communications – Timothy Pratt, Charles Bostian and Jeremy Allnutt, WSE, Wiley Publications, 2nd Edition, 2003.

References & Web Resources:

1. Timothy Pratt – Charles Bostian & Jeremy Allmuti, Satellite Communications, John Willy & Sons (Asia) Pvt. Ltd. 2004
2. Wilbur L. Pritchars Henri G. Suyder Hond Robert A. Nelson, Satellite Communication Systems Engineering, Pearson Education Ltd., Second edition 2003.
3. Satellite Communications: Design Principles – M. Richharia, BS Publications, 2nd Edition, 2003.
4. J. Gower, “Optical Communication System”, Prentice Hall of India, 2001
5. Rajiv Ramaswami, “Optical Networks “, Second Edition, Elsevier, 2004.
6. Satellite Communications Engineering – Wilbur L. Pritchard, Robert A Nelson and Henri G. Suyderhoud, 2nd Edition, Pearson Publications, 2003.
7. Optical Fiber Communication – John M. Senior – Pearson Education – Second Edition. 2007
8. Optical Fiber Communication – Gerd Keiser – Mc Graw Hill – Third Edition. 2000

Course Title	Course Code	Structure (I-P-C)		
Software Defined Radio	**EC373**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

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

CO1	Understand the SDR, CR, and their applications.
CO2	Understand the signal processing architectures used in the SDR.
CO3	Develop the FPGA based SDR.
CO4	Develop microcontroller based SDR.

Syllabus:

INTRODUCTION TO SDR: What is Software-Defined Radio, The Requirement for Software-Defined Radio, Legacy Systems, The Benefits of Multi-standard Terminals, Economies of Scale, Global Roaming, Service Upgrading, Adaptive Modulation and Coding, Operational Requirements, Key Requirements, Reconfiguration Mechanisms, , Handset Model, New Base-Station and Network, Architectures, Separation of Digital and RF, Tower-Top Mounting, BTS Hoteling, Smart Antenna Systems, Smart Antenna System Architectures, Power Consumption Issues, Calibration Issues, Projects and Sources of Information on Software Defined Radio.

BASIC ARCHITECTURE OF A SOFTWARE DEFINED RADIO: Software Defined Radio Architectures, Ideal Software Defined Radio Architecture, Required Hardware Specifications, Digital Aspects of a Software Defined Radio, Digital Hardware, Alternative Digital Processing Options for BTS Applications, Alternative Digital Processing Options for Handset Applications, Current Technology Limitations, A/D Signal-to-Noise Ratio and Power 343 Consumption, Derivation of Minimum Power Consumption, Power Consumption Examples, ADC Performance Trends, Impact of Superconducting Technologies on Future SDR Systems.

SIGNAL PROCESSING DEVICES AND ARCHITECTURES: General Purpose Processors, Digital Signal Processors, Field Programmable Gate Arrays, Specialized Processing Units, Tilera Tile Processor, Application-Specific Integrated Circuits, Hybrid Solutions, Choosing a DSP Solution. GPP-Based SDR, Non real time Radios, High-Throughput GPP-Based SDR, FPGA-Based SDR, Separate Configurations, Multi-Waveform Configuration, Partial Reconfiguration, Host Interface, Memory-Mapped Interface to Hardware, Packet Interface, Architecture for FPGA-Based SDR, Configuration, Data Flow, Advanced Bus Architectures, Parallelizing for Higher Throughput, Hybrid and Multi-FPGA Architectures, Hardware Acceleration, Software Considerations, Multiple HA and Resource Sharing, Multi-Channel SDR.

COGNITIVE RADIO : TECHNIQUES AND SIGNAL PROCESSING History and background, Communication policy and Spectrum Management, Cognitive radio cycle, Cognitive radio architecture, SDR architecture for cognitive radio, Spectrum sensing Single node sensing: energy detection, cyclostationary and wavelet based sensing- problem formulation and performance analysis based on probability of detection vs SNR. Cooperative sensing: different fusion rules, wideband spectrum sensing- problem formulation and performance analysis based on probability of detection vs SNR.

COGNITIVE RADIO: HARDWARE AND APPLICATIONS: Spectrum allocation models. Spectrum handoff, Cognitive radio performance analysis. Hardware platforms for Cognitive radio (USRP, WARP), details of USRP board, Applications of Cognitive radio.

Text Book(s):

1. "RF and Baseband Techniques for Software Defined Radio" Peter B. Kenington, ARTECH HOUSE, INC © 2005.
2. "Implementing Software Defined Radio", Eugene Grayver, Springer, New York Heidelberg Dordrecht London, ISBN 978-1-4419-9332-8 (eBook) 2013.

References & Web Resources:

1. "Cognitive Radio Technology", by Bruce A. Fette, Elsevier, ISBN 10: 0-7506-7952-2, 2006.
2. "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", Hüseyin Arslan, Springer, ISBN 978-1-4020-5541-6 (HB), 2007.

Course Title	Course Code	Structure (I-P-C)		
Cognitive Communication Networks	**EC374**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

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

CO1	Understand the Cognitive Communication and networking as per applications.
CO2	Detect the desired signal in scrambled spectrum.
CO3	Understand algorithms for of cognitive networks.
CO4	Understand the MAC protocols in cognitive networks.

Syllabus:

Introduction to Cognitive Radio: Introduction –Software Defined Radio: Architecture–Digital Signal Processor and SDR Baseband architecture – Reconfigurable Wireless Communication Systems – Digital Radio Processing –Cognitive Radio: Cognitive radio Framework – Functions – Paradigms of Cognitive Radio.

Spectrum Sensing: Introduction –Spectrum Sensing – Multiband Spectrum Sensing – Sensing Techniques – Other algorithms – Comparison – Performance Measure & Design Trade-Offs: Receiver operating characteristics – Throughput Performance measure –Fundamental limits and trade-offs.

Cooperative Spectrum Acquisition: Basics of cooperative spectrum sensing–Examples of spectrum acquisition techniques – cooperative transmission techniques – sensing strategies– Acquisition in the Presence of Interference: Chase combining HARQ –Regenerative cooperative Diversity– spectrum overlay– spectrum handoff.

MAC Protocols and Network Layer Design: Functionality of MAC protocol in spectrum access –classification –Interframe spacing and MAC challenges – QOS – Spectrum sharing in CRAHN –CRAHN models – CSMA/CA based MAC protocols for CRAHN – Routing in CRN– Centralized and Distributed protocols – Geographical Protocol.

Text Book(s):

1. Mohamed Ibnkahla, “Cooperative Cognitive Radio Networks:The complete Spectrum Cycle” I edition.
2. AhamedKhattab, Dmitri Perkins,BagdyByoumi,“Cognitive Radio Networks from Theory to practice” 2013th edition.

References & Web Resources:

1. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks, Wiley Publications

2. Alexander M.Wyglinski,MaziarNekovee, ThomasHou,” Cognitive Radio Communications and Networks”. I edition.

Course Title	Course Code	Structure (I-P-C)		
MIMO Communication Systems	**EC375**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

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

CO1	Understand the concept of MIMO communication techniques, Channel Capacity, MIMO algorithms.
CO2	Understand power allocation strategies for practical MIMO systems.
CO3	Design algorithms of MIMO to improve the bit rate.
CO4	Understand MIMO in 5G communication.

Syllabus:

Introduction: Diversity-multiplexing trade-off, transmit diversity schemes, advantages and applications of MIMO systems.

Analytical MIMO channel models: Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decomposition of MIMO channel.

Power allocation in MIMO systems:Uniform, adaptive and near optimal power allocation.

MIMO channel capacity: Capacity for deterministic and random MIMO channels, Capacity of i.i.d., separately correlated and keyhole Rayleigh fading MIMO channels.

Space-Time codes: Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes.

MIMO detection: ML, ZF, MMSE, ZF-SIC, MMSE-SIC, LR based detection.

Advances in MIMO wireless communications: Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, cognitive-femtocells and large MIMO systems for 5G wireless.

Text Book(s):

1. R. S. Kshetrimayum, Fundamentals of MIMO Wireless Communications, Cambridge University Press, 2017.
2. A. Chokhalingam and B. S. Rajan, Large MIMO systems, Cambridge University Press, 2014.

References & Web Resources:

1. B. Kumbhani and R. S. Kshetrimayum, MIMO Wireless Communications over Generalized Fading Channels, CRC Press, 2017

2. T. L. Marzetta, E. G. Larsson, H. Yang and H. Q. Ngo, Fundamentals of Massive MIMO, Cambridge University Press, 2016.

Course Title	Course Code	Structure (I-P-C)		
Detection and Estimation Theory	**EC376**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Random Process, Communication Systems

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

CO1	Understand the discrete-time and continuous-time signal theory for finding unknown signal parameters.
CO2	Extract useful information from random observations in communications.
CO3	Design and analyze optimum detection schemes.
CO4	Estimate the error in wireless communication.

Syllabus:

Detection Theory: Detection Theory in Signal Processing; the Detection Problem; the Mathematical Detection Problem; Hierarchy of Detection Problems; Role of Asymptotics.

Statistical Detection Theory: Neyman-Pearson Theorem , Receiver Operating Characteristics, Minimum Probability of Error, Multiple Hypothesis Testing, Minimum Bayes Risk Detector - Binary Hypothesis.

Deterministic Signal: Matched Filters – Development of Detector, Performance of Matched Filter; Multiple Signals – Binary case, Performance of Binary Case, M-ary case.

Random Signals: Estimator-Correlator – Energy Detector; Linear Model - Rayleigh Fading Sinusoid, Incoherent FSK for a Multipath Channel.

Estimation Theory: Estimation in Signal Processing; Mathematical Estimation Problem; Assessing Estimator Performance.

Minimum Variance Unbiased Estimation: Unbiased Estimators; Minimum Variance Criterion; Existence of the Minimum Variance Unbiased Estimator; Finding the Minimum Variance Unbiased Estimator. Estimator Accuracy Considerations; Cramer-Rao Lower Bound; General CRLB for Signals in AWGN.

Estimation Techniques: Linear Model, General Minimum Variance Unbiased Estimation, Best Linear Unbiased Estimators, Maximum Likelihood Estimation, Least Squares, Estimation.

Text Book(s):

1. Steven M. Kay, Fundamentals of Statistical signal processing, volume-1: Estimation theory. Prentice Hall 2011.
2. Steven M. Kay, Fundamentals of Statistical signal processing, volume-2:

Detection theory, Prentice Hall 2011.

References & Web Resources:

1. Harry L. Van Trees, Detection, Estimation, and Modulation Theory, Part I, John Wiley & Sons, Inc. 2011.
2. A. Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and stochastic processes, 4e. The McGraw-Hill 2010.

Free Electives

Course Title	Course Code	Structure (I-P-C)		
Electric Vehicle Technology	**EC461**	**3**	**0**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engineering, Electric Drives

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

CO1	To understand about basics of electric vehicle
CO2	To understand about drives and control.
CO3	Select battery, battery indication system for EV applications
CO4	Design battery charger for an EV

Syllabus:

Introduction to Electric Vehicle : Review of Conventional Vehicle: Introduction to Electric Vehicles: Types of EVs, Electric Drive-train, Tractive effort in normal driving.

Electric Drives : Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Energy Storage : Introduction to Energy Storage Requirements in Electric Vehicles: - Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

Energy Management System : Energy Management Strategies, Automotive networking and communication, EV charging standards, V2G, G2V, V2B, V2H. Business: E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges.

Mobility and Connectors : Connected Mobility and Autonomous Mobility- case study E-mobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs. Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards.

Text Book(s):

1. Emadi, A. (Ed.), Miller, J., Ehsani, M., “Vehicular Electric Power Systems” Boca Raton, CRC Press, 2003

2. Husain, I. “Electric and Hybrid Vehicles” Boca Raton, CRC Press, 2010.

References & Web Resources:

1. Larminie, James, and John Lowry, “Electric Vehicle Technology Explained” John Wiley and Sons, 2012
2. Tariq Muneer and Irene IllescasGarcía, “The automobile, In Electric Vehicles: Prospects and Challenges”, Elsevier, 2017
3. 5. Sheldon S. Williamson, “Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles”, Springer, 2013
4. Patents of TESLA

Course Title	Course Code	Structure (I-P-C)		
Design of IoT System	**EC462**	**3**	**0**	**3**

Pre-requisite, if any: Microprocessors and Microcontrollers.

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

CO1	Understand the networking with IoT, its enabling technologies, and explore a young, but rich, body of exciting ideas, solutions, and paradigm shifts.
CO2	Understand the potential of IoT devices, support for networking according to the protocol standards, and being able to program them, would be useful for real time applications.
CO3	Develop the rapid prototypes of IoT based embedded systems using sensors, cloud.
CO4	Develop the IoT system using Arduino, Raspberry Pi, BeagleBone Black, and Intel Edison/Galileo.

Syllabus:

Introduction to IoT: Definition, Trend, IoT applications, Sensing and Actuation, IoT Devices and deployment models, Power awareness of IoT, LDO in IoT.

IoT Networking: Basic IoT Components, Interdependencies, Service Oriented Architecture.

IoT Data Protocols: MQTT, SMQTT, CoAP, XMPP, AMQP.

IoT Communication Protocols and their applications: IEEE 802.15.4, ZigBee6LoWPAN, Wireless HART, Z-Wave, ISA 100, Bluetooth, and Bluetooth low energy (BLE), NFC, RFID, WiFi for IoT communications.

Data Handling, Analytics, Data management for IoT: Data cleaning and processing, Data storage models, Searching in IoT, Deep Web Semantic Sensor Web, Semantic web data management, Real-time and Big data analytics for IoT, High-dimensional data processing, Parallel and Distributed data processing.

Interoperability in IoT: Low power Interoperability for IPV6 IoT.

Cloud-Centric IoT: Architecture, Open Challenges, Energy efficiency, QoS, QoE.

Industrial IoT (IIoT): Industrial IoT and its benefits, Future of IIoT, Challenges, Examples.

IoT System Management and Virtualization: IoT environment management over Cloud computing framework, Fog Computing paradigm for IoT with case studies, Softwarized

control and virtualization technologies for IoT network and computation resource managements.

Case Studies: Sensor body-area-network, Smart cities and Smart homes, Agriculture.

IoT Network Framework: Wireless Network Fundamental for IoT communication tutorials with demonstrations and hands-on: 802.11 and 802.15.4 MAC Fundamentals, Management Operations, Security Overview, Network Core Protocols, Tizen Network Stack Architecture, Introduction, CAPI Architecture Overview, Sync/Async Operation Sequence, Interaction of Network Core Components, P2P Core Component Overview, OEM Layer, Supplicant Plugin Architecture overview.

Text Book(s):

1. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, by EethurumRaj and Anupama C. Raman (CRC Press).

2. Internet of Things: A Hands-on Approach, by ArshdeepBahga and Vijay Madisetti (Universities Press).

References & Web Resources:

1. AdrianMcEwen, HakimCassimally, Designing the Internet of Things,Wiley,Nov 2013, (1st edition)
2. Martin Charlier, Alfred Lui, Claire Rowland, Elizabeth Goodman, Ann Light, Designing Connected Products, May 2015, O'Reilly Media.

Course Title	Course Code	Structure (I-P-C)		
Data Communication and Networking	**EC463**	**3**	**0**	**3**

Pre-requisite, if any: Computer Networks, C Programming

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

CO1	Understand a transmission of a data in a network
CO2	Acquire knowledge of various OSI layers.
CO3	Understand topologies for specific networks.
CO4	Understand the basics of cryptography.

Syllabus:

Overview of Data Communication and Networking: Introduction; Data communications: components, data representation (ASCII, ISO etc.), direction of data flow (simplex, half duplex, full duplex); network criteria, physical structure (type of connection, topology), categories of network (LAN, MAN, WAN); Internet: brief history, Protocols and standards; Reference models: OSI reference model, TCP/IP reference model, their comparative study.

Physical Layer: Overview of data (analog & digital), signal (analog & digital), transmission (analog & digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus; Telephone Network; ATM, B-ISDN.

Data link Layer: Types of errors, framing (character and bit stuffing), error detection & correction methods; Flow control; Protocols: Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, HDLC.

Medium Access sub layer: Point to Point Protocol, LCP, NCP, Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA Traditional Ethernet, fast Ethernet (in brief).

Network layer: Internetworking & devices: Repeaters, Hubs, Bridges, Switches, Router, Gateway; Addressing: IP addressing, subnetting; Routing: techniques, static vs. dynamic routing, Unicast Routing Protocols: RIP, OSPF, BGP; Other Protocols: ARP, IP, ICMP, IPV6.

Transport layer: Process to Process delivery; UDP; TCP; Congestion Control: Open Loop, Closed Loop choke packets; Quality of service: techniques to improve QoS: Leaky bucket algorithm, Token bucket algorithm.

Application Layer: Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW; Security: Cryptography (Public, Private Key based), Digital Signature, Firewalls.

Text Book(s):

1. B. A. Forouzan, Data Communications and Networking, 4th edition, Tata McGraw Hill 2012, ISBN: 0072967757

2. A. S. Tanenbaum, Computer Networks, 4th edition, Pearson, 2013, ISBN: 978-0132126953

References & Web Resources:

1. W. Stallings, Data and Computer Communications, 5th edition, Pearson, 5th edition, 2013, ISBN: 978-0133506488.

Course Title	Course Code	Structure (I-P-C)		
Navigation System	**EC464**	**3**	**0**	**3**

Pre-requisite, if any: Nil

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

CO1	Understand the concept of GNSS, AGNSS, Radio Positioning and Integration of Navigation technique.
CO2	Analyze navigation in various terrestrial situations.
CO3	Find the exact location of an object in navigation system.
CO4	Design precision navigation systems.

Syllabus:

INTRODUCTION TO NAVIGATION: What Is Navigation, Position Fixing, Dead Reckoning, Inertial Navigation, Radio and Satellite Navigation, Terrestrial Radio Navigation, Satellite Navigation, Feature Matching, The Complete Navigation System.

NAVIGATION MATHEMATICS: Coordinate Frames, Kinematics, and the Earth: Coordinate Frames, Kinematics, Earth Surface and Gravity Models, Frame Transformations, Coriolis force.

INERTIAL NAVIGATION: Inertial-Frame Navigation Equations, Earth-Frame Navigation Equations, Local-Navigation-Frame Navigation Equations, Navigation Equations Precision, Initialization and Alignment, INS Error Propagation, Platform INS, Horizontal-Plane Inertial Navigation.

PRINCIPLES OF RADIO POSITIONING: Radio Positioning Configurations and Methods, Positioning Signals, User Equipment, Propagation, Error Sources, and Positioning Accuracy.

GNSS: FUNDAMENTALS, SIGNALS, AND SATELLITES: Fundamentals of Satellite Navigation, The Systems: Global Positioning System, GLONASS, Galileo, Beidou, REGIONAL NAVIGATION SYSTEMS: Beidou and Compass, QZSS, IRNSS, GNSS INTEROPERABILITY: Frequency Compatibility, User Competition, Multistandard User Equipment Augmentation Systems, System Compatibility, GNSS Signals, Navigation Data Messages.

ADVANCED SATELLITE NAVIGATION: Differential GNSS, Carrier-Phase Positioning and Attitude, Poor Signal-to-Noise Environments, Multipath Mitigation, Signal Monitoring, Semi-Codeless Tracking.

TERRESTRIAL RADIO NAVIGATION: Point-Source Systems, Loran, Instrument Landing System, Urban and Indoor Positioning, Relative Navigation, Tracking, Sonar Transponders. (

FEATURE MATCHING: Terrain-Referenced Navigation, Sequential Processing, Batch Processing, Performance, Laser TRN, Barometric TRN, Sonar TRN, Image Matching, Scene Matching by Area Correlation, Continuous Visual Navigation, Map Matching, Other Feature-Matching Techniques, Stellar Navigation, Gravity Gradiometry, Magnetic Field Variation. (6 hours)

INS/GNSS Integration: Integration Architectures, System Model and State Selection, Measurement Models, Advanced INS/GNSS Integration.

Text Book(s):

1. Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems, Paul D. Groves Artech House, 2008 and 2013 Second Edition.
2. B.Hofmann Wollenhof, H.Lichtenegger, and J.Collins, "GPS Theory and Practice", Springer Wien, new York, 2000.

References & Web Resources:

1. Pratap Misra and Per Enge, "Global Positioning System Signals, Measurements, and Performance," Ganga-Jamuna Press, Massachusetts, 2001.
2. Ahmed El-Rabbany, "Introduction to GPS," Artech House, Boston, 2002.
3. Bradford W. Parkinson and James J. Spilker, "Global Positioning System: Theory and Applications," Volume II, American Institute of Aeronautics and Astronautics, Inc., Washington, 1996.