Indian Institute of Space Science and Technology

Department of Space, Govt.of India
Thiruvananthapuram

Curriculum and Syllabus for

B.TECH (Electronics and Communication (AVIONICS))–R 2022

[From Academic Period 2022- 23]

(Approved By Academic Council on 27-4-22)

Version1/3-6-2022

Program Educational Objectives

- To embed technical knowledge and deep understanding in the broad area of electronics and communication engineering with exposure to the state of the art developments.
- To equip the students with strong theoretical and experimental knowledge with exposure to real-life and practical applications in electronics and communication (Avionics), and allied areas. To encourage students to utilize their knowledge in carrying out interdisciplinary research.
- To provide equal emphasis to students in acquiring substantial knowledge for leadership roles at various levels, technical skills to work in industry/R&D organizations, and creating a very strong platform for higher education/future academic research in world class institutions.
- To instill deep sense of ethics, social values, professionalism and inter-personal skills among students.

Program Specific Outcomes

- To offer in-depth knowledge and skills in the field of Electronics and Communication Engineering and allied areas which make the students ready to analyze design, optimize, implement, and solve practical problems.
- To educate and equip the students in the state of the art tools and techniques in the area of space science & technology for producing quality engineers/scientists for space industries in general and ISRO in particular.
- Enable graduates to contribute to the solution of real world practical problems in industrial, services and government organizations by applying skills acquired through continual learning.
- To practice and inculcate an ability of Independent thinking and utilizing learned knowledge in the area of Electronics and Communication for societal benefits.

COURSE STRUCTURE

Semester I

Code	Course Title	L	T	P	C
MA111	Calculus	3	1	0	4
PH111	Physics I	3	1	0	4
CH111	Chemistry	2	1	0	3
AE111	Introduction to Aerospace Engineering	3	0	0	3
MA112	Computer Programming and Applications	2	0	3	3
HS111	Communication Skills	2	0	3	3
PH131	Physics Lab	0	0	3	1
AE131	Basic Engineering Lab	0	0	3	1
Total		15	3	12	22

Semester II

Code	Course Title	L	T	P	C
MA121	Vector Calculus and Ordinary Differential Equations	2	1	0	3
PH121	Physics II	3	1	0	4
CH121	Material Science and Metallurgy	3	0	0	3
AV121	Data Structure and Algorithms	3	1	0	4
AV122	Basic Electrical and Electronics Engineering	3	1	0	4
AE141	Engineering Graphics	1	0	3	2
CH141	Chemistry Lab	0	0	3	1
Total		15	4	6	21

Semester III

Code	Course Title	L	T	P	C
MA211	Linear Algebra, Complex Analysis and Fourier Series	3	0	0	3
AV211	Analog Electronic Circuits	3	0	0	3
AV212	Digital Electronics and VLSI Design	3	0	0	3
AV213	Network Analysis	3	0	0	3
AV214	Electromagnetic Theory	3	0	0	3
HS212	Introduction to Social Science And Ethics	2	0	0	2
CH211	Environmental Science and Engineering	2	0	0	2
AV231	Analog Electronic Circuit Lab	0	0	3	1
AV232	Digital Electronics and VLSI Design Lab	0	0	3	1
Total		19	0	6	21

Semester IV

Code	Course Title	L	T	P	C
MA221	Integral Transforms, PDE and Calculus of Variations	3	0	0	3
AV221	Semiconductor Devices	3	0	0	3
AV222	Instrumentation and Measurement	3	0	0	3
AV223	Signals and Systems	3	0	0	3
AV224	Control System	3	0	0	3
HS222	Introduction to Economics	2	0	0	2
AV241	Instrumentation and Control Lab	0	0	3	1
AV242	Microprocessor and Microcontroller Lab	1	0	3	2
Total		18	0	6	20

Semester V

Code	Course Title	L	T	P	C
MA311	Probability, Statistics and Numerical Methods	3	0	0	3
AV311	Digital Signal Processing	3	0	0	3
AV312	Computer Architecture and Organization	3	0	0	3
AV313	RF and Microwave Communication	3	0	0	3
AV314	Communication System I	3	0	0	3
E1	Elective 1 (Department)	3	0	0	3
AV331	Digital Signal Processing Lab	0	0	3	1
AV332	RF and Microwave Communication Lab	0	0	3	1
Total		18	0	6	20

Semester VI

Code	Course Title	L	T	P	C
AV321	Computer Networks	3	0	0	3
AV322	VLSI Technology	3	0	0	3
AV323	Communication System II	3	0	0	3
HS321	Principles of Management Systems	3	0	0	3
E2	Elective 2 (Department)	3	0	0	3
E3	Elective 3 (Department/CBCS)	3	0	0	3
AV341	Computer Networks Lab	0	0	3	1
AV342	Communication System Lab	0	0	3	1
Total		18	0	6	20

Semester VII

Code	Course Title	L	T	P	C
E4	Elective 4 (Department)	3	0	0	3
E5	Elective 5 (Department)	3	0	0	3
E6	Elective 6 (Department)	3	0	0	3
E7	Elective 7 (CBCS/Swayam)	3	0	0	3
E8	Elective 8 (CBCS/Swayam)	3	0	0	3
E9	Elective 9 (CBCS)	3	0	0	3
AV451	Summer Internship and Training	0	0	0	3
Total		18	0	0	21

Semester VIII

Code	Course Title	L	T	P	C
AV452	Comprehensive Viva-Voice	0	0	0	3
AV453	Project Work	0	0	0	15
Total		0	0	0	18

Summary

Semester	Credits
I	22
II	21
III	21
IV	20
V	20
VI	20
VII	21
VIII	18
Total	**163**

SEMESTER I

MA111 CALCULUS (3-1-0) 4 Credits

Sequence and Series of Real Numbers: sequence – convergence – limit of sequence – non decreasing sequence theorem – sandwich theorem (applications) – L'Hopital's rule – infinite series – convergence – geometric series – tests of convergence (nth term test, integral test, comparison test, ratio and root test) – alternating series and conditional convergence – power series.

Differential Calculus: functions of one variable – limits, continuity and derivatives – Taylor's theorem– applications of derivatives–curvature and asymptotes–functions of two variables–limits and continuity– partial derivatives– differentiability,linearization and differentials–extremum of functions
– Lagrange multipliers.

Integral Calculus: lower and upper integral – Riemann integral and its properties – the fundamental theorem of integral calculus – mean value theorems – differentiation under integral sign – numerical Integration- double and triple integrals – change of variable in double integrals – polar and spherical transforms – Jacobian of transformations.

Textbooks:

1. Stewart,J.,Calculus: Early Transcendentals, 5thed.,Brooks/Cole (2007).
2. Jain,R.K.andIyengar, S.R.K., AdvancedEngineeringMathematics, Narosa (2005).

References:

1. Greenberg, M.D., Advanced Engineering Mathematics, Pearson Education (2007).
2. James, G., Advanced Modern Engineering Mathematics, Pearson Education (2004).
3. Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
4. Thomas, G.B. and Finney, R.L., Calculus and Analytic Geometry, 9th ed., Pearson Education (2003)

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand the importance of convergence of sequences and series to learn the solutions of some physical systems that are governed by Mathematical rules.
CO2	Enable students to use these notions to choose an appropriate model that is ideal for some real life situations and solve them.
CO3	Realize the importance of the concepts like limit, continuity and differentiability in modelling and solving many practical problems.
CO4	Evaluate definite integrals, areas of curved regions, arc length of a curve, volume and the surface area of revolution, and the center of mass in various dimensions

PH111	PHYSICS I	(3-1-0) 4 Credits

Vectors, Statics, and Kinematics: introduction to vectors (linear independence, completeness, basis, dimensionality), inner products, orthogonality – principles of statics, system of forces in plane and space, conditions of equilibrium – displacement, derivatives of a vector, velocity, acceleration – kinematic equations – motion in plane polar coordinates.
Newtonian Mechanics: momentum, force, Newton’s laws, applications – conservation of momentum, impulse, center of mass.
Work and Energy: integration of the equation of motion – work energy theorem, applications – gradient operator – potential energy and force interpretation – energy diagrams – law of conservation of energy – power – particle collisions.
Rotations: angular momentum – torque on a single particle – moment of inertia – angular momentum of a system of particles – angular momentum of a rotating rigid body.
Central Force Motion: central force motion of two bodies – relative coordinates – reduction to one-dimensional problem – spherical symmetry and conservation of angular momentum, consequences – planetary motion and Kepler’s laws.
Harmonic Oscillator: 1-D harmonic oscillator – damped and forced harmonic oscillators.
Modern Physics: relativity – introduction to quantum physics – atom model hydrogen atom.

Text Books:

1. Kleppner, D.and Kolenkow, R.J., An Introduction to Mechanics,2nded., Cambridge Univ.Press (2013).

References:

1. Serway, R.A. and Jewett, J.W., Principles of Physics: A Calculus Based Text, 5th ed., Thomson Brooks/Cole (2012).
2. Halliday, D., Resnick, R., and Walker, J., Fundamentals of Physics, 9th ed., John Wiley (2010).
3. Young, H.D., Freedman, R.A., Sundin, T.R., and Ford, A.L., Sears and Zemansky’s University Physics, 13th ed., Pearson Education (2011).
4.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Introduction to necessary mathematical tools and their applications to formulating and solving problems involving central forces and rigid bodies.
CO2	Introduction to the special theory of relativity and its consequences.
CO3	To open the gateway to modern physics by introducing the basics of quantum mechanics and its application to simple systems.

CH111	CHEMISTRY	(2-1-0) 3 Credits

Chemical Kinetics: basic concepts of chemical kinetics – complex reactions – effect of temperature on reaction rates – catalysis

Electrochemical Systems: introduction to electrochemistry – different types of electrodes – half cell potential–electromotive force–Gibbs free energy and cell potential–Nernst equation–electrochemical series–classification of electrochemical cells.

Corrosion Science: definition – causes and consequences – significance and methods of corrosion control–mechanisms and theories of corrosion.

Spectroscopy: fundamentals of spectroscopy – electronic spectroscopy – vibrational spec- troscopy –other spectroscopic techniques.

Propellants: classification of propellants – performance of propellants and thermo chemistry – liquid propellants – oxidizers and fuels– solid propellants – composite solid propellants.

TextBooks:

1. Atkins, P.andde Paula, J., Physical Chemistry, 9th ed., Oxford Univ.Press (2010).

References:

1. Laidler, K.J., Chemical Kinetics, 3rd ed., Pearson Education (2005).
2. Kemp, W., Organic Spectroscopy, Palgrave Foundations (1991).
3. Revie, R.W.and Uhlig, H.H., Corrosion and Corrosion Control:An Introduction to Corrosion Science and Engineering, 4thed., Wiley (2008).
4. Bockris, J.O'M.and Reddy, A.K.N.,Modern Electro chemistry1:Ionics, 2nd ed.,Springer (1998).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand and appreciate the applications of chemical kinetics in industry as well as in atmospheric science
CO2	Design/choose materials/systems and conditions for applications in engineering fields, understanding the basics of electrochemistry and corrosion
CO3	Knowledge in spectroscopic technique imparting confidence to work on novel materials for different applications
CO4	Appreciate the role of propellants in space crafts and related systems.

AE111	INTRODUCTION TO AEROSPACE	(3-0-0) 3 Credits

History of aviation – standard atmosphere – aerodynamic forces – lift generation – airfoils and wings – drag polar – concept of static stability – anatomy of an aircraft – mechanism of thrust production – propellers – jet engines and their operation – helicopters – aircraft performance – simple manoeuvres – aerospace materials and structural elements – aircraft instruments.

Elements of rocket propulsion – launch vehicle dynamics – basic orbital mechanics – satellite applications and orbits – future challenges in aerospace engineering.

Text Books:

- Same as Reference

References:

1. Anderson, D. F. and Eberhardt, S., Understanding Flight, 2nd ed., McGraw-Hill (2009).
2. Anderson, J. D., Introduction to Flight, 7th ed., McGraw-Hill (2011).
3. Szebehely, V. G. and Mark, H., Adventures in Celestial Mechanics, 2nd ed., Wiley (1998).
4. Turner, M. J. L., Rocket and Spacecraft Propulsion: Principles, Practice and New Developments, 3rd ed., Springer (2009).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understanding the fundamental ideas of aerospace engineering.
CO2	Identify the various types of aircraft and engines, including their components and purposes.
CO3	Understanding fundamental aerodynamics, flight mechanics, and propulsion concepts.
CO4	Understand and use the international standard atmosphere.
CO5	Evaluate the forces and moments.
CO6	Relationships between different disciplines.

MA112 COMPUTER PROGRAMMING AND APPLICATIONS (2-0-3) 3 Credits

Introduction to Linux – introduction to programming – basic elements of a program, variables, values, types, assignment – expressions and control flow – iteration and loop design, arrays, for loop, functions, parameters, recursion – object-oriented paradigm, objects, classes, inheritance, reusability, polymorphism, overloading, libraries, containers, classes for file handling, parameter passing and pointers, linking, shell commands.

Text Books:

1. Lippman, S.B., Lajoie, J., and Moo, B.E., C++ Primer, 5th ed., Addison-Wesley (2012).
2. Lafore, R., Object-Oriented Programming in C++, 4th ed., Sams Publishing (2001).

References:

1. Cohoon, J.P. and Davidson, J.W., Programming in C++, 3rd ed., Tata McGraw-Hill, (2006).
2. Bronson, G., A First Book of C++, 4th ed., Cengage (2012).
3. Stroustrup, B., The C++ Programming Language, 3rd ed., Pearson (2005).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Learn the procedural and object oriented paradigm with conditional statements, looping constructs and functions.
CO2	Understand the concepts of streams, classes, functions, data and objects.
CO3	Understand dynamic memory management techniques using pointers, constructors, destructors, etc
CO4	Apply the concept of function overloading, operator overloading, virtual functions and polymorphism.

HS111 COMMUNICATION SKILLS (2-0-3) 3 Credits

Functional English: conversation skills – asking questions, requests, doubts, engage in conversation – different types of communication - verbal and non-verbal, body language.
Teaching Grammar: grammar games, exercises.
Teaching Vocabulary: language games, exercises.
Reading and appreciating stories, poems, essays – listening and appreciating video lectures – comprehensive questions and answers.

Lab: Presentation skills – appreciation of videos, songs – role plays – debates – extemporizes – group presentations – introduction to technical writing – technical writing, how to write minutes, reports, and project proposals.

TextBooks/ References:

1. Garner, A., Conversationally Speaking: Tested New Ways to Increase Your Personal and Social Effectiveness, McGraw-Hill (1997).
2. Bechtle, M., Confident conversation: how to communicate successfully in any situation, revell (2008).
3. Brown, S. and Smith, D., Active Listening with Speaking, Cambridge Univ. Press (2007).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand and learn the significance of effective communication skills through learning life skills which are not hinged on traditional pedagogy.
CO2	Improved listening, speaking, reading and writing skills and confidence to become successful English speakers.
CO3	Understand significance of verbal and non-verbal communication in their personal and professional life
CO4	Enhance the students body language, social etiquette, presentation skills, interview skills, assertive communication skills, active listening and technical writing skills.
CO5	Develop critical and creative thinking by becoming active components in the nation building

PH131 PHYSICS LAB (0-0-3) 1 Credits

- Damped driven oscillator
- Waves and oscillation
- Modulus of elasticity
- Surface tension
- Moment of inertia and angular acceleration
- Faraday's law of induction
- Biot-Savarts law
- Ratio of electronic charge to mass
- Brewster's angle and Malu's law
- Earth's magnetic field
- Charge of an electron

TextBooks /References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	To learn how to set up an experiment to test a hypothesis.
CO2	Familiarization with the methods of curve fitting of experimental data and error analysis.
CO3	To perform experiments that apply the theoretical knowledge acquired in Physics I and Physics II courses.

AE131 BASIC ENGINEERING LAB (0-0-3) 1 Credits

- Study of general purpose hand tools in workshop
- Assembly and disassembly practices of the following models
  - Gear box assembly
  - Centrifugal pump assembly along with shaft alignment practice
  - Cam and follower mechanisms
  - Transducer (sensor) trainer
- Experiments on different basic machines
  - Turning exercise–straight turning,taper turning,thread cutting practice
  - Milling exercise –spur gear cutting practice
  - Welding practice –arc welding
  - Fitting practice– models with marking and drilling exercises

Electrical Wiring Practice
Soldering Practice

TextBooks/References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Familiarization of basic mechanical elements, assemblies and mechanisms
CO2	Familiarization of hand tools, cutting tools and measuring instruments used in engineering workshop
CO3	Familiarization of general purpose machines and processes in engineering workshops.
CO4	Familiarization of soldering and wiring

SEMESTER II

MA121	VECTOR CALCULUS AND ORDINARY DIFFERENTIAL	(2-1-0) 3 Credits

Vector Calculus: scalar and vector fields – level surfaces – directional derivatives, gradient, curl, divergence – Laplacian – line and surface integrals – theorems of Green, Gauss, and Stokes.

Sequences and Series of Functions: complex sequences – sequences of functions – uniform convergence of series – test for convergence – uniform convergence for series of functions.

Ordinary Differential Equations: first-order ordinary differential equations – classification of differential equations – existence and uniqueness of solutions of the initial value problem – higher-order linear differential equations with constant coefficients – method of variation of parameters and method of undetermined coefficients – power series solutions – regular singular point – Frobenius method to solve variable coefficient differential equations.

Special Functions: Legendre polynomials, Bessel's function, gamma function, and their properties – Sturm-Liouville problems.

TextBooks:

1. Ross, S.L., Differential Equations, Blaisedell (1995).
2. Kreyszig, E., Advanced Engineering Mathematics, 9th ed., John Wiley (2005).
3. Stewart, J., Calculus: Early Transcendentals, 5th ed., Brooks/Cole (2007).

References:

1. Greenberg, M.D., Advanced Engineering Mathematics, Pearson Education (2007).
2. Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics, Narosa (2005).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Differentiate between pointwise and uniform convergence, check whether a given series is pointwise or uniformly convergent series, and apply the techniques to integral and differential calculus.
CO2	Analyze and solve ODEs, confirm existence and uniqueness of solutions of IVP. Find power series solution of linear homogeneous ODE with variable coefficients and Frobenius method for equations with regular singular point. Know the special functions like Legendre

	polynomial, Bessel function etc. and properties. Finding eigenvalues and eigenfunctions for Sturm-Liouville problems.
CO3	Verify continuity/differentiability of scalar/vector-valued function. Calculate line/surface integration of scalar/vector-valued functions. Apply fundamental theorems to understand the nature of vector fields and check if a given vector field is conservative.

PH121 PHYSICS II (3-1-0) 4 Credits

Electricity: curvilinear coordinates – conservative vector fields and their potential functions – Gauss'theorem, Stokes' theorem – physical applications in electrostatics – electrostatic potential and field dueto discrete and continuous charge distributions – dipole and quadrupole moments – energy density in an electric field – dielectric polarization – conductors and capaci-tors – electric displacement vector – dielectric susceptibility.

Magnetism:Biot–Savart'slaw and Ampere's law in magnetostatics–magnetic induction due to configurations of current-carrying conductors – magnetization and surface currents – energy density in a magnetic field – magnetic permeability and susceptibility – force on a charged particle in electric and magnetic fields – electromotive force, Faraday's law of electromagnetic induction – self and mutual inductance,displacement current.

Optics: nature of light – ray approximation in geometrical optics – reflection – refraction, Fer-matsprinciple – dispersion – mirrors and lenses – aberrations – interference – diffraction –polarization – lasers.

TextBooks:

1. Griffith, D.J., Introduction to Electrodynamics, 4th ed., Prentice Hall (2012).
2. Hecht, E., Optics, 4th ed., Pearson Education (2008).

References:

1. Feynman, R.P., Leighton, R.B., and Sands, M., The Feynman Lectures on Physics, Narosa (2005).
2. Reitz, J.R., Milford, F.J., and Christy, R.W., Foundations of Electromagnetic Theory, 3rd ed., Narosa (1998).
3. Wangsness, R.K., Electromagnetic Fields, 2nd ed., Wiley (1986).
4. Sadiku, M.N.O., Elements of Electromagnetics, 6th ed., Oxford Univ. Press (2014).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Introduction to tools of vector calculus and their applications in the formulation of electromagnetic theory via Maxwell's equations.
CO2	Familiarization with various techniques, such as multipole expansions, for solving problems in electrostatics and magnetostatics.
CO3	Introduction to electrodynamics and familiarization with its formulation in terms of tensors.

CH121 MATERIAL SCIENCE AND METALLURGY (3-0-0) 3 Credits

Selection of materials – structure of solids, crystal structure – defects in crystals, free energy concept – alloying – principles of solidification – phase diagrams – concept of heat treatment – properties of materials, mechanical, electrical, thermal and optical properties – testing of materials – semiconductor materials – ceramics, synthesis and processing – polymers, classification, mechanism of formation, structure property relations, characterization – composites, classification, factors influencing properties, processing.

Textbooks:

1. Callister Jr., W. D., Materials Science and Engineering: An Introduction, 7th ed., John Wiley (2007).
2. Raghavan V., Physical Metallurgy: Principles and Practice, 3rd ed., PHI Learning (2015).

References:

1. Billmeyer, F. W., Textbook of Polymer Science, 3rd ed., Wiley India (1984).
2. Askeland, D. R. and Phule, P. P., The Science and Engineering of Materials, 4th ed., Thompson-Engineering (2006).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand the fundamental principles of materials science.
CO2	Appreciate the applications of different classes of materials in day today life as well as in strategic sectors
CO3	Evaluate the properties of materials for and applying in different applications

AV121	DATA STRUCTURE AND ALGORITHMS	(3-1-0) 4 Credits

Time Complexity Analysis: Big-Oh, Big-Omega, and Big-Theta notations.
Data Types and Abstract Data Types (ADTs):Various types of ADTs such as List, Set, Queue, Circular Queue, Trees, Graphs, etc.2-3 Trees, Red-Black Trees, Binary Trees, Search Trees, N-ary Trees.
Graph Traversals and Searching:
BFS (Breadth-First Search), DFS (Depth-First Search), Spanning Tree, Minimum Spanning Tree, Paths, Shortest Paths, TSP (Traveling Salesman Problem).Data Structures for Maintaining Ranges, Intervals, and Disjoint Sets with Applications.
Binary Heap, Binomial and Fibonacci Heaps, Skip Lists, Hashing, Universal Hashing. Integer Sorting Algorithms with Analysis. Algorithm Design:Greedy, Divide and Conquer, Dynamic Programming, Branch and Bound, Randomized Algorithms. Advanced Data Structures.

Textbooks/References:

1. Gregory L. Heileman, Data Structure, Algorithm, and OOP, Tata McGraw-Hill, New Delhi.
2. Adam Drozdek, Data Structures & Algorithms in C++, Vikas Publication House.
3. Aho, Hopcroft, and Ulmann, Data Structures and Algorithms, Pearson, 1982
4. T. Cormen, C. Leiserson, R. Rivest, and C. Stein, Introduction to Algorithms, 3rd Ed., MIT Press, 2009.
5. Debasish Samanta, Classic Data Structures, Prentice Hall India Learning Private Limited, 2009.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Compare different programming methodologies and define asymptotic notations to analyze performance of algorithms.
CO2	Use appropriate data structures like arrays, linked list, stacks and queues to solve real world problems efficiently.
CO3	Represent and manipulate data using nonlinear data structures like trees and graphs to design algorithms for various applications.
CO4	Illustrate and compare various sorting and searching techniques including hashing.

AV122	BASIC ELECTRICAL AND ELECTRONICS	(3-1-0) 4 Credits

DC Circuit Analysis: Network Theorems - Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum power transfer theorem.
AC Circuit Analysis: Basic concepts of AC circuits – RMS value and average value – Behavior of resistor, capacitor, and inductor in AC circuits – Sinusoidal steady-state analysis of AC circuits – Power factor - Resonance in AC circuits. Introduction To Magnetic Theory.
Diode: Clipping, clamping circuits, applications in rectifiers and power supplies.
Amplifiers: BJT - Characteristics - DC analysis and AC analysis of BJT. Application of BJT as amplifiers/switch.
Introduction to Operational Amplifiers: Characteristics/specifications and application circuits.
Digital Circuits: Boolean logic – basic gates – truth tables – logic minimization using K-maps – combinatorial and sequential circuits.

Textbooks:

1. Boylestad, R. L. and Nashelsky, L., Electronic Devices and Circuit Theory, Pearson Education (2003).
2. Mano, M. M., Digital Design, Prentice Hall (2002).
3. Same as Reference (Electrical Part).

References:

1. Vincent DelToro: Electrical Engineering Fundamentals, Pearson Education, 1989.
2. A. E. Fitzgerald, David E Higginbothom, Arvin Grabel: Basic Electrical Engineering, Tata McGraw-Hill, 2010.
3. Hughes, E.: Electrical and Electronic Technology, Pearson Education, 2008.
4. Charles K Alexander, Mathew N. O. Sadiku: Electric Circuits, McGraw-Hill; 4th edition, 2008.
5. Fitzgerald, Kingsley, Umans: Electric Machinery, Tata McGraw-Hill, 2017.
6. M. G. Say: Performance and Design of AC Machines, CBS; 3rd edition, 2002.
7. Mittle, V. N. and Mittal, A.: Electrical Engineering, 2nd ed., Tata McGraw-Hill, 2005.
8. Cotton, H.: Principles of Electrical Engineering, Sir Isaac Pitman & Sons, 1967.
9. Mottershed, A.: Electronic Devices and Circuits: An Introduction, EEE Publication, 12th Indian ed., 1989.
10. Bapat, Y. N.: Electronic Devices and Circuits, Tata McGraw-Hill, 9th ed., 1989.
11. Malvino, A. P.: Electronic Principles, 12th ed., 3rd TMH ed., Tata McGraw-Hill, 1989.
12. Jain, R. P.: Modern Digital Electronics, McGraw-Hill, 2004.
13. Floyd, T. L.: Electronic Devices, Pearson Education, 8th ed., 2007.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Demonstrate Proficiency in DC Circuit Analysis
CO2	Apply AC Circuit Analysis Techniques
CO3	Understanding of the characteristics of diodes and transistors
CO4	Understanding of the operational circuits and its design
CO5	Realize digital circuits using basic gates

AE141 ENGINEERING GRAPHICS (1-0-3) 2 Credits

Introduction and Importance of Engineering Graphics: Sheet layout and free-hand sketching – lines, lettering, and dimensioning – geometrical constructions – engineering curves – orthographic projection – first angle and third angle projections – projection of points, straight lines, and planes – projection of simple solids – sections of solids – development of surfaces – isometric projection – introduction to AutoCAD – creation of simple 2D drawings.

Textbooks:

1. Bhatt, N. D., Engineering Drawing: Plane and Solid Geometry, 50th ed., Charotar Publishing House (2010).

References:

1. Jolhe, D. A., Engineering Drawing with an Introduction to AutoCAD, Tata McGraw-Hill (2008).
2. Venugopal, K. and Prabhu Raja, V., Engineering Drawing + AutoCAD, 5th ed., New Age International (2011).
3. Varghese, P. I., Engineering Graphics with AutoCAD, 26th ed., VIP Publishers (2012).
4. Luzadder, W. J. and Duff, J. M., Fundamentals of Engineering Drawing, 11th ed., Pearson Education (2015).
5. Bethune, J. D., Engineering Graphics with AutoCAD 2014, Pearson Education (2014).

Outcomes (COs):

Course Outcomes	Statements
CO1	Read and interpret engineering drawings
CO2	Creating orthographic, and isometric views
CO3	Improving visualization skills
CO4	Use CAD software for creating drawings and concepts

CH141 CHEMISTRY LAB (0-0-3) 1 Credits

1. Determination of total hardness of water
2. The Nernst equation
3. Potentiometry
4. Conductometry
5. Determination of phosphoric acid content in soft drink
6. Determination of chloride content in water
7. Validation of Ostwalds dilution law and solubility product
8. Kinetics of acid hydrolysis of ester
9. Kinetics of sucrose inversion
10. Preparation of polymers
11. Determination of molecular weight of polymers
12. Metallography of steels
13. Microhardness of different materials

Text Books / References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand to handle instruments in electrochemistry experiments
CO2	Analyze techniques for characterization of different classes of materials
CO3	Analyze the results from the experiments and draw conclusions

SEMESTER III

MA211	**LINEAR ALGEBRA, COMPLEX ANALYSIS AND FOURIER SERIES**	**(3-0-0) 3 Credits**

Linear Algebra: matrices; solution space of system of equations Ax=b, eigenvalues and eigenvectors, Cayley-Hamilton theorem – vector spaces over real field, subspaces, linear dependence,independence, basis, dimension – inner product – Gram-Schmidt orthogonalization process – linear transformation; null space and nullity, range and rank of a linear transformation.

Complex Analysis: complex numbers and their geometrical representation – functions of complex variable – limit, continuity and derivative of functions of complex variable – analytical functions and applications – harmonic functions – transformations and conformal mappings – bilinear transformation – contour integration and Cauchys theorem – convergent series of analytic functions – Laurent and Taylor series – zeroes and singularities – calculation of residues – residue theorem and applications.

Fourier Series and Integrals: expansion of periodic functions with period 2_ – Fourier series of even and odd functions – half-range series – Fourier series of functions with arbitrary period –conditions of convergence of Fourier series – Fourier integrals.

Textbooks:

1. Kreyszig, E., Advanced Engineering Mathematics, 10th ed., John Wiley (2011).
2. Mathews, J. H. and Howell, R., Complex Analysis for Mathematics and Engineering,Narosa (2005).

References:

1. Brown, J. W. and Churchill, R. V., Complex Variables and Applications, 9th ed., McGraw-Hill (2013).
2. Greenberg, M. D., Advanced Engineering Mathematics, Pearson Education (2007).
3. Jain, R. K. and Iyengar, S. R. K., Advanced Engineering Mathematics, 4th ed., AlphaScience Intl. Ltd. (2013).

Course Outcomes (CO) :

Course Outcomes	Statements
CO1	Understand the basic concepts of vector space and subspaces
CO2	Determine rank and nullity of space and matrix of linear Transformation
CO3	Understand basic concepts of analytic functions and harmonic functions
CO4	Evaluate integrals of features using Cauchy’s theorem and Cauchy integral formula
CO5	Apply Taylor’s and Laurent’s series expansion and find singularities of function
CO6	Understand the convergence of Fourier series and evaluate Fourier series of periodic and even functions

AV211 ANALOG ELECTRONIC CIRCUITS (3-0-0)3Credits

Basic stability and device stabilization techniques (BJT). Small signal low & high frequency models for (BJT, FET, MOSFET), Large signal amplifiers, Differential Amplifier, Instrumental amplifiers, Integrated circuits, Tuned amplifiers, Feedback amplifiers, Oscillators, Multivibrators, Wave shaping circuits, Filter design.

Basic stability and device stabilization techniques (BJT). Small signal low & high frequency models for (BJT, FET, MOSFET). Large signal amplifiers - Multistage amplifiers - Differential amplifier - Tuned amplifiers - Feedback amplifiers – Power amplifiers - Instrumental amplifiers. Oscillators – Multivibrator - Wave shaping circuits - Active Filter design - Integrated circuits (PLL, Timers, A/D converters)

.

Textbooks:

1. J. Millman and C.C. Halkias, Integrated Electronics - Analog and Digital circuit system, McGraw Hill, 1996.

References:

1. David A.Bell, Electronic Devices and Circuits, Prentice Hall of India, 2006.
2. Donal L. Schilling and Charles Beloue, Electronic Circuits, Third Edition, McGraw Hill, 2005.
3. David A. Bell, Solid State Pulse Circuits, Prentice Hall of India, 1992.
4. John D. Ryder, Electronic Fundamental and Applications - Integrated and Discretesystem, Prentice Hall of India, 1999.
5. J. Millman and H. Taub, Pulse Digital and Switching waveform-Devices and circuits, McGraw Hill International, 1965.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understanding the concept of small signal operation and biasing techniques for BJTs and MOSFETs
CO2	Analysis and design of amplifiers using BJTs and MOSFETs
CO3	Understanding concepts of frequency response, noise, feedback, non-linearity in electronic systems
CO4	Analysis and design of differential amplifiers, instrumentation amplifiers, tuned amplifiers and power amplifiers
CO5	Design of wave-shaping circuits, oscillators and multivibrators using transistors, opamps and timer ICs
CO6	Design of a complete analog electronic system with real-world component variation and temperature dependence

AV212	DIGITAL ELECTRONICS AND VLSI DESIGN	(3-0-0) 3 Credits

Boolean Algebra, Standard Representation, and Minimization Procedures: Logic families, combinational circuits, asynchronous and synchronous sequential circuits, Memories, PROMs and PLAs. Introduction to VLSI systems - CMOS logic - MOS transistor theory - Layout design rules - Circuit characterization and performance estimation - Circuit simulation - Combinational and sequential circuit design - Static and dynamic CMOS gates - Memory system design - Design methodology and tools - HDL. Design of FPRG, Complex CMOS design.

Textbooks:

1. Morris Mano, Digital Design, 4th ed., Prentice-Hall of India, 2006.
2. John F. Wakerly, Digital Design Principles and Practice, 3rd edition, Pearson Education, 1990.

References:

1. William I. Fletcher, An Engineering Approach to Digital Design, Prentice-Hall of India, 1980.
2. T. L. Floyd, Digital Fundamentals, Charles E. Merrill publishing Company, 1982.
3. R. L. Tokheim, Digital Electronics - Principles and Applications, Tata McGraw Hill, 1999.
4. R. P. Jain, Modern Digital Electronics, Tata McGraw Hill, 1999.
5. N. Weste and D. Harris, CMOS VLSI Design: Circuits and Systems Perspective, Addison Wesley, 2004.
6. Wayne Wolf, Modern VLSI Design, Prentice Hall, 1998.
7. Peter J. Ashenden, The Designer's Guide to VHDL, Harcourt Asia private Limited & Morgan Kauffman, 1996.
8. Douglas A. Pucknell and Kamran Eshraghian, Basic VLSI Design Systems and Circuits, Prentice Hall of India, 1993.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand basics of logic gates, and minimization of Boolean equations and its combinational circuit implementation
CO2	Design combinational logic circuits for adder, subtractor and other arithmetic/control functionality
CO3	Design and analyze the synchronous sequential circuits and asynchronous sequential circuits, timing parameters and its implementation
CO4	Understand basics of VLSI Design, TTL logic family, electrical characteristics of digital logic gate, CMOS implementation of logic gate and fundamentals of CMOS device characteristics of inverter, layout rules and design .
CO5	Learning to design and analyze CMOS static and dynamic circuits
CO6	Learning to design digital circuits using hardware description Language

AV213	NETWORK ANALYSIS	(3-0-0) 3 Credits

Time domain analysis: Transients in electrical circuits - RL, RC and RLC circuits, DC and AC circuits, switched capacitor circuits, conservation of charge, passive filters, resonance in networks, magnetic circuits and magnetically coupled circuits.

Laplace domain analysis: Laplace transform basics, initial and final value theorems, properties of Laplace transforms, initial value problems, applications of Laplace transforms for networks solving

Two-port networks, graph theory and network synthesis.

Textbooks:

1. Van Valkenbarg, M. E., Network Analysis, 3rd Ed., Prentice-Hall, 2007.
2. Kuo, F. F., Network Analysis and Synthesis, 2nd Ed., Wiley India, 2008.

References:

1. Murthy, K. V. V. and Kamath, M. S., Basic Circuit Analysis, Tata McGraw-Hill, 1989.
2. DeCarlo, R. A. and Lin, P. M., Linear Circuit Analysis: Time Domain, Phasor and Laplace Transform Approaches, Oxford University Press, 2003.
3. Ramakalyan, A., Linear Circuit Analysis and Synthesis, Oxford University Press.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Learning signals, conventions and definitions used in steady state and transient analysis of electrical networks
CO2	Analysis of transients in 1st and 2nd order networks in time domain for different excitations and circuit configurations for standalone as well as coupled circuits
CO3	Understanding the fundamentals of Laplace transform and application of LT in network analysis.
CO4	Analysis of network in frequency domain and designing 1st and 2nd order analog passive and active filters as a precursor to network synthesis.

AV214	**ELECTRO MAGNETICS THEORY**	**(3-0-0) 3 Credits**

Review of Maxwell's Equations – Boundary Conditions – Pointing Vector.
Electromagnetic Waves: Wave equation & Uniform Plane waves – Plane waves in lossy and lossless mediums – Normal and oblique incidences of plane waves.
Transmission Line Theory: LCR model for transmission lines – Analogy with wave equations – characteristics of lossless lines – VSWR, Impedance matching – Smith chart – Case study.
Waveguides: TEM, TE, TM Waves – wave propagation in Rectangular, Circular & Planar waveguides.
Fundamentals of Antenna: Radiation – Wire antenna – Gain and Directivity. Introduction to antenna arrays.

Textbooks:

1. D. K. Cheng, Field and Wave Electromagnetics, Pearson Education.
2. RK Shevgaonkar, Electromagnetic Waves, Tata McGraw-Hill Education.
3. C. A. Balanis, Antenna Theory: Analysis and Design, John Wiley & Sons.

References:

1. E. C. Jordan & K. G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall of India, 2nd edition, 2003.
2. M. N. O. Sadiku, Elements of Engineering Electromagnetics, Oxford University Press, Third edition.
3. Ramo, Whinnery and Van Duzer, Fields and Waves in Communications Electronics, John Wiley & Sons, 3rd edition, 2003.
4. William H. Hayt, Engineering Electromagnetics, Tata McGraw-Hill, 7th edition.
5. J. D. Kraus, Antennas, McGraw-Hill, 2nd Edition.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand and apply the fundamental concept of electrostatics and magnetostatics
CO2	Understand the wave equations & boundary conditions and apply the same in different cases
CO3	Familarize the characteristics of EM wave and its propagation in various mediums and apply the same in various applications and practical scenarios
CO4	Familiarize and understand the concept of transmission lines and its in depth analysis
CO5	Analyze, understand and design rectangular and circular waveguides
CO6	Understand the overview & basics of antennas and propagation

HS212	INTRODUCTION TO SOCIAL SCIENCE AND ETHICS	(2-0-0) 2 Credits

Social Science**:** Introduction to sociology, anthropology – social science research design and sampling.

Ethics**:** Professional and personal ethics – values & norms and human rights.

Textbooks:

1. Lecture Notes.

References:

1. Perry, J. and Perry, Contemporary Society: An Introduction to Social Science, 11th ed., Allyn & Bacon (2005).
2. Giddens, A., Sociology, 5th Edition. Wiley (2006).
3. Flyvberg, B., Making Social Science Matter, Cambridge Univ. Press (2001).
4. Singer, P., A Companion to Ethics, Wiley-Blackwell (1993).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Holistic understanding about society and awareness of humanitarian and social issues
CO2	Application of the sciences for the improvement of the quality of life
CO3	Enhancing the analytical capabilities of students and cultivate critical thinking
CO4	Understand ethics and values of life and its application in professional and personal life

CH211	ENVIRONMENTAL SCIENCE AND ENGINEERING	(2-0-0) 2 Credits

Awareness of the Impact of Environment on Quality of Life: Natural resources – biological systems – bio-geochemical cycles – chemical processes; water treatment operations, water sampling, storage, quality measurement – oxygen demand – detection of pollutants – current environmental issues; pollutants, global warming, causes and consequences, air pollution, organic and inorganic air pollutants, smog – acid mine drainage, accumulation of salts in water – soil formation; micro and macro nutrients in soil, pollutants in soil – green chemistry: an alternative tool for reducing pollution – engineering interventions; flow sheets, waste minimization, e-waste management, ASP, reverse osmosis, trickling filter – environmental management; solid, liquid waste management, hazardous wastes, ISO standards – Kyoto protocol, Montreal protocol, Euro norms.

Textbooks:

1. Rao, V., Textbook of Environmental Engineering, Prentice Hall of India (2002).

References:

1. Baird, C. and Cann, M., Environmental Chemistry, 3rd ed., W.H. Freeman and Company (2005).
2. Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, GOI (1999).
3. Manual on Sewerage and Sewage Development, CPHEEO, Ministry of Urban Development, GOI (1993).
4. Hauser, B. A., Practical Hydraulics Handbook, Lewis Publishers (1991).
5. Hammer, M. J., Water and Waste water Technology, Regents/Prentice Hall (1991).
6. Sharma, J. P., Comprehensive Environmental Studies, Laxmi Publications (2004).
7. Garg, S. K., Environmental Engineering (Vol. 1 and 2), Khanna Publishers (2004).
8. Kiely, G., Environmental Engineering, McGraw-Hill (1997).
9. Bharucha, E., Textbook of Environmental Studies, University Grants Commission (2004).
10. Van Loon, G. W. and Duffy, S. J., Environmental Chemistry: A Global Perspective, Oxford Univ. Press (2000).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand biological, physical, and industrial processes relevant to environmental problems
CO2	Understand the causes and effects of environmental problems, and explain engineering solutions.
CO3	Apply their knowledge of environmental science and engineering to specific scenarios or problems and analyze case studies related to environmental challenges, design sustainable engineering solutions, or implement eco-friendly practices within their organizations/society.
CO4	Analyse the ethical reflection regarding environmental problems in local, regional, national, and global communities and the importance of systemic study and evaluation of the environment during any initiative or plans.
CO5	Enable to make judgments and critique the effectiveness of environmental policies, strategies, and

	solutions.
CO6	Enable to nurture knowledge, respect, and protect the environmental resources and design solutions in the realm of environmental science and engineering.

AV231 ANALOG ELECTRONIC CIRCUIT LAB (0-0-3) 1 Credits

- Analog Electronics

1	Design of a voltage source using BJT
2	Design of a switch using BJT/MOSFET
3	Design of inverting, non-inverting and unity gain amplifiers using op-amps
4	Design of constant current source using opamp
5	Design of a common emitter amplifier with a specified gain
6	Design of a common collector amplifier to drive a load
7	Design of a CE-CC amplifier
8	Design of wein-bridge oscillator
9	Design of function generator
10	Design of Monostable multivibrator
11	Design of schmitt trigger with different thresholds
12	Design of a power amplifier

Text Books/ References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Designing DC circuits using transistors - applying biasing techniques
CO2	Designing amplifiers for a given specifications and measuring frequency response of amplifiers
CO3	Design of wave-shaping circuits, oscillators and multivibrators using opamps and timer IC
CO4	Design of a complete analog electronic system with real-world component variation and temperature dependence

AV232 DIGITAL ELECTRONICS AND VLSI DESIGN LAB (0-0-3) 1 Credits

1. Design and implementation of combinational circuits using basic gates for arbitrary functions, code converters, parity generator / checker, magnitude comparator etc.
2. Design and implementation of application using multiplexers, Decoders/encoders.
3. Design and implementation of synchronous & asynchronous sequential circuit.
4. FPGA and Programming.

Text Books / References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Learning to design, analyze and realizing logic gates of transistor Level circuits using discrete level components, static and dynamic performance parameters of the gates
CO2	Hands on training on designing and realizing (i) combinational logic circuits of parallel adders, multiplexers using discrete components and SSI/MSI chips (ii) sequential circuits realizing flip flops, registers, counters using IC chips
CO3	Simulate and analyze Logic circuits using HDL language
CO4	Design simulate and analyze logic circuits-adders, ALU, memories, sequence detector using HDL and implement it in FPGA
CO5	Design simulate and analyze controller designs/FSM for interfaces in FPGA
CO6	Design of digital system using Verilog and implement in FPGA

SEMESTER IV

MA221	INTEGRAL TRANSFORM, PDE AND CALCULUS OF VARIATIONS	(3-0-0) 3 Credits

Integral Transforms: The Fourier transform pair – algebraic properties of Fourier transform – convolution, modulation, and translation – transforms of derivatives and derivatives of transform – inversion theory. Laplace transforms of elementary functions – inverse Laplace transforms – linearity property – first and second shifting theorem – Laplace transforms of derivatives and integrals – Laplace transform of Dirac delta function – applications of Laplace transform in solving ordinary differential equations.

Partial Differential Equations: introduction to PDEs – modeling problems related and general second order PDE – classification of PDE: hyperbolic, elliptic and parabolic PDEs – canonical form – scalar first order PDEs – method of characteristics – Charpits method – quasi-linear first order equations – shocks and rare factions – solution of heat wave and Laplace equations using separable variable techniques and Fourier series.

Calculus of Variations: optimization of functional–Euler-Lagrange equations – first variation – is operimetric problems – Rayleigh- Ritz method.

Textbooks:

1. Kreyszig, E., Advanced Engineering Mathematics, 10th ed., John Wiley (2011).

References:

1. Wylie, C.R. and Barrett, L.C., Advanced Engineering Mathematics, McGraw-Hill (2002).
2. Greenberg, M.D., Advanced Engineering Mathematics, Pearson Education (2007).
3. James, G., Advanced Modern Engineering Mathematics, 3rd ed., Pearson Education (2005).
4. Sneddon, I.N., Elements of Partial Differential Equations, McGraw-Hill (1986).
5. Renardy, M. and Rogers, R.C., An Introduction to Partial Differential Equations, 2nd ed., Springer-Verlag (2004).
6. McOwen, R.C., Partial Differential Equations: Methods and Applications, 2nd ed., Pearson Education (2003).
7. Borelli, R.L., Differential Equations: A Modelling Perspective, 2nd ed., Wiley, 2004.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Evaluate and Understand Fourier transforms and Laplace trasforms
CO2	Understanding Linear First order Partial differential equations and second order PDE
CO3	Evaluate problems using Charpits method, PDEs using separation of variables, second order PDE with constant and variable coefficient
CO4	Understand the concept of maxima and minima of functionals and Isoperimetric problems

AV221	SEMI CONDUCTOR DEVICES	(3-0-0) 3 Credits

Semiconductor fundamentals, crystal structure, concept of effective-mass, Fermi level, energy-band diagram, concept of holes, intrinsic and extrinsic semiconductors, carrier concentration, carrier transport, scattering and drift of electrons and holes, drift and diffusion, generation and recombination, quasi-Fermi levels.

Semiconductor junctions, Physical description of p-n junction, p-n junction under forward and reverse bias, current – voltage characteristics and temperature dependence, tunneling current and tunnel diode, small signal ac analysis.

Hetero junctions and Schottky junctions, Bipolar Junction Transistors, base width modulation, frequency limitations, pnpn diode, SCR, MOS capacitor, flat-band and threshold voltages, MOSFETs, scaling laws of MOS transistors.

Optical absorption in a semiconductor, photovoltaic effect, solar cell, photo conductors, PIN photodiode, avalanche photodiode, LED, semiconductor LASER, negative conductance in semiconductors, transit time devices, IMPATT, Gunn device, IGBT.

Textbooks /References:

1. S.M. Sze, Semiconductor Physics and Devices, Wiley Student Edition, 2007.
2. Ben G. Streetman and Sanjay Kumar Banerjee, Solid State Electronic Devices, Dorling Kindersley, 2007.
3. Robert F. Pierret, Semiconductor Device Fundamentals, Prentice Hall of India, 2007.
4. Donald Neamen, Semiconductor Physics and Devices, McGraw publishers.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand basic concepts of semiconductor theory including band diagrams, carrier transport, carrier concentrations, doping and continuity equation. Analyze continuity equations for various scenarios.
CO2	Understanding basic steps of fabricating p-n junction, depletion region, built-in voltage, energy band diagrams and operation of diodes
CO3	Analyze the operation of Tunnel diode and Metal-Semiconductor junctions. Apply energy band concepts to Heterojunctions, Alloyed semiconductors and Bandgap engineering
CO4	Formation of bipolar junction transistors and operation, Early effect, MOS capacitor, CV characteristics

AV222 INSTRUMENTATION AND MEASUREMENT (3-0-0) 3 Credits

Introduction to Measurement and Instrumentation, Static Characteristics of Instruments; Types of Errors, Statistical Error Analysis, Propagation of Errors; Dynamic Characteristics of Instrumentation Systems, Sensor Reliability; Basic Analog Measuring Instruments (PMMC, Electrodynamometer, Rectifier) and its use as Electronic Voltmeter and Ammeter. Wattmeter and Energy Meters; High Current/Voltage Measurement – C.T., P.T., C.V.T; Null-Based Measurement - D.C. and A.C. Potentiometer, Wheatstone Bridge Circuits, Low and High Resistance Measurement, Bridges for Measurement of Inductance and Capacitance, Wagner-Earth Connection; Typical Circuits in Measurement - Differential and Instrumentation Amplifier, Filters, Current Sources, Precision Rectifiers, V-to-F Converters; Digital Measurement Systems: Frequency and Time-Period Meters, Phase-Angle Measurement; Digital Voltage Measurement, DMM, Sample & Hold Circuits, A/D Converters and Comparative Study, D/A Circuits; General Instruments - CRO, DSO and Probes, Function Generator, Spectrum Analyzers, Data Acquisition Systems; Transducers & Signal Conditioning: Resistive Sensors (Potentiometers, Strain Gauges and Load Cell, Torsion Bars, RTD, Thermistor); Inductive Transducers (Variable Reluctance Sensors, LVDT, Tachogenerator) and Capacitive Transducers; Temperature Sensors (Thermocouple, Semiconductor), Light Sensing Devices, Piezoelectric Sensors, Pressure Sensors.

Text Books:

1. Doebelin, E.O., Measurement systems: Application and Design, 5th ed., McGraw hill, 2003.
2. Albert D. Helfrick, William D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall of India Private Limited.

References:

1. J. G. Webster, The Measurement, Instrumentation and Sensors Handbook, Vol 1 and 2, CRC Press, 1999
2. Golding E.W. and Widdis F.E., Electrical measurements and measuring instruments, Sir Issac Pitman and Sons pvt ltd, 1995.
3. 3.John P. Bentley, Principle of Measurement Systems, Pearson Education; 3rd Edition, 2006.
4. L. K. Baxter, Capacitive Sensors – Design and Applications, IEEE Press Series on Electronic Technology, NJ (1997).
5. M. B. Stout, Basic Electrical Measurements, Prentice Hall Pvt. Ltd., India, New Delhi, 1982.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understanding the various (static, dynamic, long-term) specifications and characteristics of sensors and instrumentation systems.
CO2	Understanding the principles of various analog meters and measurement strategies for voltage, current, power and impedance estimation.
CO3	Analyze typical measurement/interface circuits used to build instrumentation systems

CO4	Understanding the principles of digital instrumentation and internal architecture of standard equipment such as digital multimeters, function generators, oscilloscopes, etc.
CO5	Analyze various transduction principles andoperation of typical sensors and specific design guidelines and practical issues in sensors, interface electronics and instrumentation systems.

AV223	SIGNALS AND SYSTEMS	(3-0-0) 3 Credits

Classification of signals and systems, Types of signals, Transformation of independent variable, Periodic signals and Periodicity, Types of systems, Analysis of Continuous Time Signals and LTI systems: Convolution, Impulse response, Trigonometric and exponential Fourier series, Eigen functions of LTI systems, Fourier Transform, Magnitude and Phase Spectra, Properties of Fourier Transform, Laplace Transform, Region of Convergence, Properties, Linear Constant coefficient Differential Equations, State Space Matrix for continuous time systems.

Analysis of Discrete Time Signals and LTIDT systems: Periodicity, Discrete Convolution, DFT, Properties, Z Transform, ROC, Properties, Difference Equations, State variable equation and matrix, some applications – signal processing, communication, control systems etc.

Textbooks:

1. R.F. Ziemer, W.H. Tranter and D.R. Fannin, Signals and Systems - Continuous and Discrete, Prentice Hall, 2006.
2. B.P. Lathi, Linear Systems and signals, 2nd edition, Oxford University Press, 1998.
3. Simon Haykin, Barry Van Veen, Signals and Systems, John Wiley and Sons (Asia) PrivateLimited, 2005.
4. A.V. Oppenheim, A.S. Willsky and I.T. Young, Signals and Systems, Prentice Hall, 2006.

References:

1. Douglas K. Lindner, Introduction to Signals and Systems, Mc-Graw Hill International,1999.
2. Robert A. Gabel, Richard A. Roberts, Signals and Linear Systems, John Wiley and Sons (SEA) Private Limited, 1995.
3. M. J. Roberts, Signals and Systems - Analysis using Transform methods and MATLAB,Tata McGraw Hill, 2003.
4. J. Nagrath, S. N. Sharan, R. Ranjan, S. Kumar, Signals and Systems, Tata McGraw Hill, New Delhi, 2001.
5. Ashok Ambardar, Analog and Digital Signal Processing, 2nd Ed., Brooks/ Cole Publishing Company, 2006.
6. A. Papoulis, Circuits and Systems: A Modern Approach, HRW, 1980.
7. B.P. Lathi, Signal Processing and Linear Systems, Oxford University Press, 1998

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Interpret discrete time and continuous time linear time invariant systems in time domain.

CO2	Analyze Continuous time signals and system applying Fourier and Laplace concepts.
CO3	Analyze Discrete time signals and system applying DTFT and Z transforms.
CO4	Apply the significance of discrete systems in signal processing, communication and control systems.

AV224	CONTROL SYSTEM	(3-0-0) 3 Credits

Control Systems: Introduction to Control Theory - Control System Components, Modeling of Physical Systems - Transfer Function, Block Diagram, Signal-Flow Graph, and State-Space Representation. Time Domain and Frequency Domain Response - Relationship between the Time and Frequency Domain Responses. Stability - Concept of Pole and Zero - Routh-Hurwitz Criteria, Nyquist Criteria, Root Locus, and Bode Plot; P-I, P-D, P-I-D Controller Design, Tuning of Controllers; Lead and Lag Compensators. State Variable Representation and Solution of State Equations of LTI Control Systems.

Textbooks:

1. Katsuhiko Ogata, Modern Control Engineering, 4th Edition, Prentice Hall of India publishers, New Delhi, 2006.

References:

1. Gopal I and Nagrath N, Control systems, Wiley Eastern Ltd, New Delhi, 1985.
2. Norman S Nise, Control Systems Engineering, Wiley India, 4th edn, 2003
3. D'Azzo, Houpis, Feedback Control System Analysis and Synthesis, CRC Press, 2007.
4. M.Gopal, Control systems, Principle and Design, Tata McGraw Hill publishing Co, New Delhi, 1997.
5. Kuo B.C., Automatic control systems, Prentice Hall India ltd, New Dehli, 1995.
6. Mutambara, Design and Analysis of Control Systems, CRC Press, 2008
7. Xue, Chen, Atherton, Linear Feedback Control Analysis and Design with MATLAB, SIAM Publications, 2006.
8. Qiu, Zhou, Introduction to Feedback Control, Prentice Hall, 2009.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand and differentiate between open loop and closed loop control systems
CO2	Model a physical system and analyse its transient behaviour and steady state characteristics
CO3	Analyse stability of linear time invariant systems and familiarise with stability concept
CO4	Design simple controllers like PID and lag-lead compensators for LTI systems

HS222	INTRODUCTION TO ECONOMICS	(2-0-0) 2 Credits

Exploring the Subject Matter of Economics: Why We Study Economics – Types - Definitions – Economic Systems – Economics as a Science. Principles and Concepts of Microeconomics: Demand – Supply – Production – Costs – Markets - Equilibrium. Basics of Macroeconomics: Role of Government – National Income Concepts – Inflation Concepts – Classical vs. Keynesianism. Economic Problems and Policies: Meaning of Development – Problems of Growth – Population – Agriculture and Industry – Balance of Payments – Planning – Study Report Related to Economics of Space Program.

Textbooks:

1. Samuelson, Paul A. and William D. Nordhaus, Economics, 17th ed., McGraw-Hill (2005).
2. Dewett, K. K., Modern Economic Theory, 22nd ed., S. Chand & Co.
3. Thirlwall, A. P., Growth and Development with Special Reference to Developing Economies, Palgrave (2003).

References:

1. Gardner, A., Macroeconomic Theory, Surjeet Publications (1998).
2. Koutsoyiannis, A., Modern Microeconomics, 2nd ed., Palgrave Macmillan (2003).
3. Black, J., A Dictionary of Economics, Oxford Univ. Press (2003).
4. Meir, J. M. and Rauch, J. E., Leading Issues in Economic Development, 7th ed., Oxford Univ. Press (2005).
5. Todaro, M. P. and Smith, S. C., Economic Development, 8th ed., Pearson Education Ltd. (2008).
6. Economic Survey 2008, Government of India, Ministry of Finance.
7. O'Connor, D. E., The Basics of Economics, Greenwood Press (2004).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand economic problems for better development of technology
CO2	Develop theoretical and analytical skills to make firm level decisions using various principles of economics.
CO3	Equip to handle the dynamics of production and business to understand and handle the dynamics of economics and business of the changing world economy
CO4	Solve economic problems through engineering and scientific solutions for development challenges of the country
CO5	Understand real-life problems and technology solutions, strengths and weaknesses of the economy, sensitize about real life issues and become better engineers and scientists.

AV241	INSTRUMENTATION AND CONTROL LAB	(0-0-3) 1 Credits

1. Study of sensors (e.g., LVDT, Temperature and Optical Sensors, Strain gauge) and their signal conditioning techniques
2. Illustration of measurement of process-variables such as pressure, flow, level, etc., and various calibration principles.
3. Evaluation of different filter circuits (e.g., Sallen-Key Low-Pass filter, Twin-T notch filter, All-Pass filters) and phase detector schemes.
4. Typical Measurement Circuits - Instrumentation amplifier and CMRR studies, Low current measurement techniques, Precision rectifiers, Charge amplifiers
5. Virtual Instrumentation Using LABVIEW and Data Acquisition. Direct-Digital converters for sensors
6. Introduction to Open Loop and Close Loop Simulation using Matlab/Simulink
7. Controller Design:
   Time domain Specifications: Root locus Method
   Frequency Domain Specifications: Bode Plot, Nyquist Stability Method
8. Modeling, Simulation, Control of Physical Systems – Matlab/Simulink based Simulation
9. Control design and Hardware in Loop Simulation for:
   Inverted Pendulum
   Magnetic Levitation System
10. Modeling and Simulation of Engine Gimbal Control Systems for Launch Vehicle

TextBooks/References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Interpreting and evaluation of commonly used sensors and their signal conditioning circuits
CO2	Design and experimentation of different electronic circuits used for measurement and instrumentation
CO3	Design and evaluation of digital instrumentation techniques
CO4	Analyze and evaluate control system design techniques
CO5	Apply control design principles to physical systems
CO6	Synthesize control solutions for complex systems

AV242 MICROPROCESSOR AND MICROCONTROLLER LAB (1-0-3) 2 Credits

1. Programming with 8086 – 8-bit / 16-bit multiplication/division using repeated addition/subtraction.
2. Programming with 8086 - code conversion, decimal arithmetic, bit manipulations.
3. Programming with 8086 - matrix multiplication, floating point operations.
4. Programming with 8086 – String manipulation, search, find and replace, copy operations, sorting. (PC Required)
5. Experiment based on Interfacing and control application
6. PIC/ATmel Microcontroller based experiments – Simple assembly language programs (cross assembler required).
7. PIC/ATmel Microcontroller based experiments – Simple control applications (cross assembler required).

Text Books / References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand the fundamentals of Microprocessors
CO2	Understand the internal design of Microprocessors /8051 microcontroller along with the features and their programming
CO3	Design different interfacing applications using Microprocessors and peripherals.
CO4	Understand the fundamentals of PIC Microcontroller
CO5	Design different interfacing applications using Microcontrollers and peripherals.

SEMESTER V

MA311 PROBABILITY, STATISTICS AND NUMERICAL METHODS (3-0-0) 3 Credits

Probability Theory: Elementary concepts on probability – axiomatic definition of probability – conditional probability – Bayes' theorem – random variables – standard discrete and continuous distributions – moments of random variables – moment generating functions – multivariate random variables – joint distributions of random variables – conditional and marginal distributions – conditional expectation – distributions of functions of random variables – t and χ^2 distributions – Schwartz and Chebyshev inequalities – weak law of large numbers for finite variance case – central limit theorem for iid finite variance case.

Statistics: Elementary concepts on populations, samples, statistics – sampling distributions of sample mean and sample variance – point estimators and its important properties – point estimator for mean and variance and proportion – confidence interval for sample mean – tests of hypotheses – Chi-squared test of goodness of fit.

Numerical Methods: Solution of algebraic and transcendental equations – system of linear algebraic equations – interpolation – numerical integration – numerical solution of ordinary differential equations – system of nonlinear algebraic equations.

Textbooks:

1. Walpole, W. E., Myers, R. H., Myers, S. L., and Ye, K., Probability & Statistics for Engineers & Scientists, 9th ed., Pearson Education (2012).
2. Jain, M. K., Iyengar, S. R. K., and Jain, R. K., Numerical Methods for Scientific and Engineering Computation, 4th ed., New Age International (2005).

References:

1. Johnson, R. A., Miller & Freund's Probability and Statistics for Engineers, 6th ed., Prentice Hall (2000).
2. Milton, J. S. and Arnold, J. C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 4th ed., McGraw-Hill (2002).
3. Ross, S. M., Introduction to Probability and Statistics for Engineers and Scientists, 3rd ed., Academic Press (2004).
4. Hogg, R. V. and Tanis, E. A., Probability and Statistical Inference, 7th ed., Prentice Hall (2005).
5. Larsen, R. J. and Marx, M. L., An Introduction to Mathematical Statistics and Its Applications, 4th ed., Prentice Hall (2005).
6. Conte, S. D. and de Boor, C., Elementary Numerical Analysis, 3rd ed., TMH (2005).
7. Krishnamurthy, K. V., Numerical Algorithms, Affiliated East-West Press (1986).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Learn fundamental concepts of probability, statistics and numerical methods in detail to enable students to identify the relevance of these concepts and apply them in the modelling and performance analysis of several electronics and communication systems.
CO2	Understand random variables and their probability distributions chosen to model various random phenomena arising in models of systems.
CO3	Analyse sampling theory to understand the information in a sample to estimate system parameters.
CO4	Understand various standard numerical techniques to apply them appropriately in the modelling and analysis of several engineering systems.

AV311	DIGITAL SIGNAL PROCESSING	(3-0-0) 3 Credits

Discrete time signals and systems, Properties of LTI Systems, DTFT, Z-T/F; Minimum phase-All pass decomposition, Generalized linear phase; DFS, Frequency sampling and Time aliasing, DFT, Periodic & Circular convolutions; FFT computations using DIT and DIF algorithms; Infinite Impulse Response Digital Filter design: Impulse invariant and Bilinear transformation approaches, Finite Impulse Response Digital filter design: Windowing and Optimal Equiv.-ripple filter design; Filter structures and realization: Signal flow graph representation, Direct form I & II, Cascade and Parallel forms, Finite Word length effect; Introduction to Multirate Signal Processing: Fractional sampling rate conversion, Poly-phase decomposition; Importance of Short-time Fourier transform; Introduction to programmable DSPs - Architecture of TMS 320C5X.

Textbook:

1. Alan V Oppenheim, Ronald W Schafer, John R Back, Discrete Time Signal Processing, PHI, 2nd Edition 2000
2. John G Proakis, Dimtris G Manolakis, Digital Signal Processing Principles, Algorithms and Application, PHI, 3rd Edition, 2000.
3. B.Venkataramani & M. Bhaskar, Digital Signal Processor Architecture, Programming and Application, TMH 2002.

References:

1. Avtar Singh, S.Srinivasan, DSP Implementation using DSP microprocessor with Examples from TMS32C54XX, Thamson / Brooks cole Publishers, 2003
2. S.Salivahanan, A.Vallavaraj, Gnanapriya, Digital Signal Processing, McGraw-Hill / TMH, 2000.
3. Johny R.Johnson, Introduction to Digital Signal Processing, Prentice Hall, 1984.
4. S.K.Mitra, Digital Signal Processing- A Computer based approach, Tata McGraw-Hill,1998, New Delhi.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Analyze the discrete time systems and signals in transform domain
CO2	Design and realize the filter with minimum hardware resources
CO3	Apply the adaptive algorithm to vary the coefficient of the filter in variable environment
CO4	Implement the discrete time system with different sampling rate
CO5	Apply the signal processing technique or concepts in the various fields like biomedical, communication, control, machine learning etc.

AV312 COMPUTER ARCHITECTURE AND ORGANIZATION (3-0-0) 3 Credits

Introduction to computer organization: Structure and function of a computer - Processing unit: Characteristics of CISC and RISC processors - Performance of a processing unit. Memory subsystem: Memory hierarchy - Main memory unit - Internal organization of a memory chip - Organization of a main memory unit - Error correction memories - Interleaved memory units - Cache memory unit - Concept of cache memory - Mapping functions - organization of a cache memory unit - Fetch and Write mechanisms - Memory management unit - Concept of virtual memory - Address translation - hardware support for memory management. Input / Output subsystem: Access of I/O devices - I/O ports - I/O control mechanisms - Program controlled I/O - Interrupt controlled I/O - DMA controlled I/O - I/O interfaces - System buses - peripherals - Terminals - Video displays - Magnetic storage disks - magnetic tapes - CD ROMs. High-Performance processors: Instruction pipelining - Pipeline - Hazards - Superscalar processors - Performance considerations. Multi-processor systems: Shared memory systems - Interconnection networks - Caches in multiprocessor systems.

Textbook/References:

1. Tanenbaum A.S., Structured computer organization, 4th edition, PHI, 1999.
2. Hayes, J.P, Computer architecture and Organisation, McGraw Hill, 1998.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understanding the architecture and organization of modern digital computers
CO2	Design of computer architectures, memory subsystem, Input/Output subsystem, and the whole system.
CO3	Understanding the Design and operation of multicore computer architectures and high performance processors
CO4	Conducting research literature review and preparation of literature survey writeups for computing architecture and organization
CO5	Develop innovative thinking process in the area of advanced computer architectures and organization

AV313	RF AND MICROWAVE COMMUNICATION	(3-0-0) 3 Credits

Scattering matrix parameters, Transmission matrix, Signal flow graph, Impedance matching, Single and double stub tuning, problems. Microwave wave-guide and planar-based passive devices, Microwave resonators, Power dividers, directional couplers, and filters, Isolator, Circulator, phase shifter, Microwave signal generators: Klystron, magnetron, and TWT. Microwave systems design, Microwave Amplifier design, Gain and stability, Oscillator design, Broadband systems, noise figure, and link budget.

Textbooks:

1. David M. Pozar, Microwave engineering, 2nd Ed., John Wiley & Sons, Inc. 2004.

References:

1. R.E. Collin, Foundations for Microwave Engineering, McGraw-Hill, 1992.
2. S.M. Liao, Microwave Devices and Circuits, Prentice Hall Of India Private Limited.
3. P.A. Rizzi, Microwave Engineering, Prentice-Hall, Englewood Cliffs, NJ, 1988.
4. T.S. Laverghetta, Modern Microwave Measurements and Techniques, Artech House,Norwood, MA, 1988

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Analyze microwave networks using S parameter.
CO2	Designing different types of matching circuits using concept of lumped, distributed circuit matching.
CO3	Design and realization of different microwave passive devices- importance of odd and even mode analysis to realize different passive devices.
CO4	Understand concepts of microwave filter design, different design principle, filter trnasformation technique, Butterworth and Chebyshev design lumped filter, stepped impedance filter design.

AV314	COMMUNICATION SYSTEM I	(3-0-0) 3 Credits

Fundamental of communication systems, signals and information, system block diagram, performance metrics and data rate limits. Review of Fourier series and Transforms – Energy/Power Spectral Density.

Introduction to carrier modulation - Amplitude modulation, AM spectrum, power relations, double sideband suppressed carrier (DSBSC) and single sideband modulation (SSB) schemes, DSBSC/SSBSC spectrum, Vestigial sideband modulation and spectrum. Generation of AM signals, modulators and transmitters, product modulators, square-law modulators and balanced modulators. Frequency translation and frequency division multiplexing, Propagation characteristics of AM signals.

Frequency modulation (FM), Narrowband FM, Wideband FM, FM spectrum, Transmission bandwidth, Generation of FM signals: direct and indirect methods. Phase modulation-relationship between FM and PM signals. Radio Receivers - TRF and super-heterodyne receivers, Image frequency, Intermediate frequency (IF), Automatic gain control. AM demodulation - coherent detection, envelope (non-coherent) detection of AM signals, DSB-SC and SSB demodulation. FM demodulation - Basic FM demodulators, Amplitude limiting, ratio detector, PLL based FM detection, Pre-emphasis and de-emphasis in FM.

Textbooks / References:

1. Lathi BP. Modern Digital and Analog Communication Systems 3e. Oxford University Press, 1998
2. John G Proakis and M. Salehi, Communication systems engineering, Prentice Hall, 1994.
3. Rodger E. Ziemer, and William H. Tranter. Principles of communications. John Wiley & Sons, 2014.
4. Simon Haykin. Communication systems. John Wiley & Sons, 2008.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand and apply linear system theory, Fourier transforms, Laplace transforms for mathematical modelling and performance analysis of analog communication systems without noise
CO2	Understand subsystems in baseband and passband analog communication systems
CO3	Apply probability theory and stochastic processes for mathematical modelling and performance evaluation of analog communication systems
CO4	Create a functional design of an analog communication system which meets given requirements by a proper choice of different subsystems and their parameters, and by doing link analysis
CO5	Apply the knowledge gained from this course for understanding current analog communication systems and challenges

E01	**ELECTIVE I**	**(3-0-0) 3 Credits**

- **Refer list of Electives**

AV331	DIGITAL SIGNAL PROCESSING LAB	(0-0-3) 1 Credits

1. Study of DFT
2. IIR Filter Design
3. FIR Filter Design
4. FIR Kaiser and Equiripple Filter Design
5. Comparison of FIR and IIR Filter Design
6. Study of Simulink and Signal Processing Tool Box
7. Multirate Signal processing
8. DSP Processor,TMS 320C6713,DSK Experiments
9. TMS 320C6713-Real Time Processing

Text Books / References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Skills to analyze the discrete time systems and signals in transform domain
CO2	Ability to formulate the specification for the given application and able to design and realize the filter with minimum hardware resources
CO3	Ability to apply the adaptive algorithm in the design of adaptive filter
CO4	Implement the discrete time system with different sampling rate

AV332	RF AND MICROWAVE COMMUNICATION LAB	(0-0-3) 1 Credits

RF Experiments

1. Analyze the radiation patterns of the different antennas.
2. Experiments on Coaxial Line Section:
    a. Measurement of VSWR
    b. Measurement of unknown impedance
    c. Stub matching
    d. Measurement of Gain and Noise figure
3. Simulation and Testing of RF Circuits:
    a. RF Tuned Amplifier
    b. RF Oscillator
    c. RF Crystal Oscillator
    d. IF Amplifier
    e. RF Mixer
    f. RF Filters (LP, HP, BP, Notch Filter)
4. Stability

Microwave Experiments

1. Characteristics of Reflex Klystron Oscillator
2. Characteristics of Gunn Diode Oscillator
3. Study of Power Distribution in directional coupler, E / H Plane Tee, Magic Tee.
4. Radiation pattern of Horn Antenna.
5. Frequency Measurement
6. Impedance measurement by Slotted Line Method.

Text Books / References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Basic Familiarization with the Microwave Waveguide based bench set-up and their individual blocks/subsystems. Performance study of high power microwave sources such as Gunn and Klystron and the study of standing waves in the bench and its different parameters.
CO2	Time Domain reflectometry (TDR) to characterize different cables suitable for different frequency.
CO3	Study of frequency response in spectrum analyzer and vector network analyzer. Familiarization of different antenna patterns through experiment.

CO4	Hands on training about working with ADS (Advanced design software) to complement the understanding of theory course AV 313.

SEMESTER VI

AV321	COMPUTER NETWORKS	(3-0-0) 3 Credits

Introduction to Computer Networks: Network Topology, Layered Protocol Stack, Point-to-point and broadcast communications, LAN, WAN, MAN, and the Internet.

Delay analysis in circuit switching, message switching, and packet switching. Queuing models.

Application Layer Protocols: Domain Name System, Hyper Text Transfer Protocol (HTTP), File Transfer Protocol (FTP), SMTP/E-mail Applications, Voice over IP, and P2P protocols.

Transport Layer protocols: Transport layer protocol design, Congestion control, reliability, quality of service, TCP, UDP, (optional SCTP) protocols, and throughput analysis.

Network Layer Protocols: Routing process, Link state and distance vector protocols, time complexity of algorithms, routing metrics, Routing in the Internet, RIP, BGP, Addressing in the Internet, IPV4, IPV6.

Medium access protocols: Aloha, CSMA and its variations, Ethernet; Token Ring; Framing and Error Control Techniques; Throughput analysis of MAC protocols. Error Control Techniques; Flow control; Bridges, Repeaters, Switches and the spanning tree protocol.

Text Books:

1. James Kurose and Keith Ross, Computer Networking: A Topdown Approach, 6th Edition, Pearson Education, 2012.

References:

1. Andrew S. Tannenbaum and D.J. Wetherall, Computer Networks, PHI, 5th Edition, 2010
2. William Stallings, Data and Computer Communications, 10th Edition, Pearson Education, 2013.
3. Dimitry Bertsakes and Robert Gallager, Data Networks, 2nd edition, Pearson Education, 1992..

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understanding the basics of Internet, its operations, and delay analysis
CO2	Understand the layered protocol stack and its operation. Understand the protocols in application, transport, network, and datalink layers and their design objectives
CO3	Conduct experiments to capture packets, analyze them, understand them, and interpret them
CO4	Conducting research literature review/documentation/writeups for computer networks
CO5	Develop innovative thinking process in the area of computer networks, Internet-enabled devices, or services over the internet

AV322	VLSI TECHNOLOGY	(3-0-0) 3 Credits

Classical scaling in CMOS, Moore's Law, Clean room concept, Material properties, crystal structure, lattice, characterization of material based on band diagram and bonding, conductivity, resistivity, sheet resistance, phase diagram and solid solubility.

Growth of single crystal Si, Wafer Cleaning and etching-Wet etch, Dry etch, Plasma etching, RIE etching, etch selectivity/selective etch, Lithography (Photolithography, EUV lithography, X-ray lithography, e-beam lithography etc.) Next generation technologies: Immersion lithography, Phase shift mask, ion lithography, SCALPEL.

Thermal oxidation-Kinetics, Characterization of oxide films, High k and low k dielectrics for ULSI Impurity incorporation: Solid State diffusion modeling and technology, Ion Implantation modeling, technology and damage annealing, characterization of Impurity profiles, Deposition & Growth (PVD, CVD, ALD, epitaxy, MBE, ALCVD etc.),Metal film deposition: Evaporation and sputtering techniques.

Planarization Techniques: Need for planarization, Chemical Mechanical Polishing Process integration for NMOS CMOS and Bipolar circuits, Back end of line processes (Copper damascene process, Metal interconnects; Multi-level metallization schemes) Advanced MOS Technologies.

Text Books / References:

1. James Plummer, M. Deal and P.Griffin, Silicon VLSI Technology, Prentice Hall Electronics
2. Stephen Campbell, The Science and Engineering of Microelectronics, Oxford University Press, 1996
3. S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 1988
4. C.Y. Chang and S.M.Sze (Ed), ULSI Technology, McGraw Hill Companies Inc, 1996.
5. S.K. Ghandhi, VLSI Fabrication Principles, John Wiley Inc., New York, 1983.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand advance transistors and related devices followed by scaling rules for modern CMOS.
CO2	Analyze short channel devices, and realize CMOS
CO3	Understand CMOS process and evaluation of technology from generation to generation.
CO4	Ability to read and analysis the recent journals regarding the development of VLSI technology.

AV323	COMMUNICATION SYSTEM II	(3-0-0) 3 Credits

Signal space concepts: Geometric structure of the signal space, vector representation, distance, norm and inner product, orthogonality, Gram-Schmidt orthogonalization procedure.
Matched filter receiver, Inter symbol interference, Pulse Shaping, Nyquist criterion for zero ISI, Signaling with duobinary pulses, Eye diagram, Equalizer, Scrambling and descrambling.
Review of Gaussian random process, Optimum threshold detection, Optimum Receiver for AWGN channel, Matched filter and Correlation receivers, Decision Procedure: Maximum aposteriori probability detector- Maximum likelihood detector, Error probability performance of binary signaling.
Digital band pass modulation schemes: ASK, FSK, PSK, MSK – Digital M-ary modulation schemes – signal space representation Detection of signals in Gaussian noise - Coherent & non-coherent detection – Differential modulation schemes – Error performance of binary and M-ary modulation schemes – Probability of error of binary DPSK – Performance of M-ary signaling schemes in AWGN channels - Power spectra of digitally modulated signals, Performance comparison of digital modulation schemes.

Textbooks / References:

1. Lathi BP. Modern Digital and Analog Communication Systems 3e. Oxford University Press, 1998
2. John G Proakis and M. Salehi, Communication systems engineering, Prentice Hall, 1994.
3. Rodger E. Ziemer, and William H. Tranter. Principles of communications. John Wiley & Sons, 2014.
4. Simon Haykin. Communication systems. John Wiley & Sons, 2008.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand discrete time system theory, DTFT, DFT, FFT, z- transforms for mathematical modelling of discrete time communication systems
CO2	Understand and apply probability theory and stochastic processes for mathematical modelling and performance analysis of SNR, bit error rate, power spectral density of point to point digital communication systems
CO3	Analyze various subsystems for baseband and passband processing of digital communication systems such as equalizers, synchronizers, modulation and demodulation schemes
CO4	Evaluate given requirements for a digital communication system and apply that for designing parameters for various subsystems via link budget analysis
CO5	Apply the knowledge gained from this course for understanding modern wired and wireless digital communication systems

HS321	PRINCIPLES OF MANAGEMENT SYSTEMS	(3-0-0) 3 Credits

Personnel Management**:** Introduction – changing role of personnel manager – new people management – manpower planning – recruitment and selection – performance appraisal – workers participation in management – grievance handling.

Industrial Management**:** Management Functions – organization – principles of planning –management by objectives – organization structures – principles of organizing – span of control – delegation, leadership, directing, and controlling.

Project Management: Development of project network – project representation – project scheduling – linear time-cost trade-offs in projects: a heuristic approach – project monitoring and control with PERT.

Textbooks / References:

1. Koontz H., O'Donnel, C., and Weihrich, H., Essentials of Management, McGraw-Hill (1990).
2. Venkataratnam, C. S. and Srivastava, B. K., Personnel Management and Human Resources, Tata McGraw-Hill (1991).
3. Mazda F., Engineering Management, Prentice Hall (1997).
4. Gido, J. and Clements, J. P., Successful Project Management, 2nd ed., South-Western College Publishing (2003).
5. Khanna, O. P., Industrial Engineering and Management, Dhanpat Rai Publications (P) Ltd. (2003).
6. Memoria, C. B. and Gankar, S. V., Personnel Management - Text and Cases, Himalaya Publishing House (2007).

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand the scope, objectives, and functions of management in theoretical and practical settings.
CO2	Understand the roles and apply the skills needed by a manager to do the jobs efficiently and effectively
CO3	Apply CPM and PERT techniques for planning, scheduling and controlling of projects
CO4	Apply quantitative techniques in management to solve real-world problems for improved decision-making

E02	**ELECTIVE 2 (DEPARTMENT)**	**(3-0-0) 3 Credits**

- **Refer list of Electives**

E03	**ELECTIVE 3 (DEPARTMENT/CBCS)**	**(3-0-0) 3 Credits**

- **Refer list of Electives**

AV341 COMPUTER NETWORKS LAB (0-0-3) 1 Credits

1. Network traffic capture and analysis
2. Application layer network traffic and content analysis (DNS,HTTP,etc.)
3. Connection-less and Connection-oriented sessions
4. Client-server socket programming for UDP
5. Client-server socket programming for TCP
6. TCP-connection establishment analysis
7. TCP-congestion control and flow control analysis
8. Iterative and concurrent server implementation study
9. Network layer and routing protocols
10. Queuing theory simulation study
11. MAC layer experiments
12. Network simulator study

TextBooks/References:

1. Lab Manual
2. W.Richard Stevens, BillFenner, Andrew M. Rudoff, Unix Network Programming, The Sockets Networking API, Volume 1: 3rd Edition, Addison-Wesley Professional 2003.
3. James Kurose and Keith Ross, Computer Networking: A Top down Approach, 6th Edition, Pearson Education, 2012.
4. Andrew S.Tannenbaum and D.J.Wetherall, Computer Networks, PHI, 5th Edition, 2010.
5. William Stallings, Dataand Computer Communications, 10th Edition, Pearson Education, 2013.
6. Dimitry Bertsakes and Robert Gallager, Data Networks, 2nd edition, Pearson Education, 1992.

AV342	COMMUNICATION SYSTEM LAB	(0-0-3) 1 Credits

- Basic signals and systems in Matlab/Python
- Spectral analysis and filtering - simulations in Matlab/Python
- Simulation of baseband communication systems - study of line coding and its rate, bandwidth properties. Study of bit error rate
- Simulation of passband communication systems - study of different constellations and its rate, bandwidth properties. Simulation of correlation receiver. Study of bit error rate.
- Simulation of bandlimited channels and intersymbol interference. Implementation and study of equalization schemes
- Implementation and study of frame and timing synchronization methods (marker based and early-late scheme)
- Carrier synchronization - simulation of a basic PLL
- Implementation and study of an end to end digital communication link - (based on time - SDR based demonstrations)

Text Books / References:

- Lab Manual

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Apply basic programming techniques in Matlab or Python to simulate signal processing operations (including spectral analysis, filtering, convolution)
CO2	Apply Matlab or Python to simulate baseband and passband communication systems and evaluate their performance via bit error rate and other performance metrics.
CO3	Design and then apply Matlab or Python to simulate various subsystems for baseband and passband processing of digital communication systems such as equalizers, synchronizers, modulation and demodulation schemes
CO4	Create an end to end simulation in Matlab or Python for a digital communication system and evaluate its performance.

SEMESTER VII

E04	**ELECTIVE 4 (DEPARTMENT)**	**(3-0-0) 3 Credits**

- **Refer list of Electives**

E05	**ELECTIVE 5 (DEPARTMENT)**	**(3-0-0) 3 Credits**

- **Refer list of Electives**

E06	**ELECTIVE 6 (DEPARTMENT)**	**(3-0-0) 3 Credits**

- **Refer list of Electives**

E07	**ELECTIVE 7 (CBCS/SWAYAM)**	**(3-0-0) 3 Credits**

- **Refer list of Electives**

E08	**ELECTIVE 8 (CBCS/SWAYAM)**	**(2/3-0-0) 2/3 Credits**

- **Refer list of Electives**

E09	**ELECTIVE 9 (CBCS/SWAYAM)**	**(2/3-0-0) 2/3 Credits**

- **Refer list of Electives**

AV451 SUMMER INTERNSHIP AND TRAINING (0-0-0) 3 Credits

Summer Internship and training is to be carried out during the summer vacation after 6th semesters. The intership is for a period of 6 weeks. Students should submit a report of summer internship for evaluation. The students can do the internship under faculty of IIST, ISRO centers or in other industries/institutes with intership oppurtunities.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Apply theoretical knowledge gained in classrooms to real-world engineering problems.
CO2	Design, implementing, and troubleshooting electronic circuits, communication systems, or other relevant technologies.
CO3	Analyze engineering problems, identify solutions, and implement effective strategies.
CO4	Develop proficiency in specialized software tools, equipment, or programming languages relevant to ECE

SEMESTER VIII

AV452 COMPREHENSIVE VIVA-VOCE (0-0-0) 3 Credits

The syllabus for a comprehensive viva voce examination typically covers a wide range of topics covered in the previous semesters. The evalution is done to assess the understanding and knowledge of the students across various aspects of their field.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Remember fundamental concepts, theories, principles, and definitions in various areas of electronics and communication engineering.
CO2	Understanding, problem-solving abilities, and critical thinking in engineering problems
CO3	Ability to articulate technical concepts, and ethical considerations in engineering practice.
CO4	Apply their learning effectively in diverse engineering fields
CO5	Compare and contrast different design approaches/solutions

AV454 PROJECT WORK (0-0-0) 15 Credits

The project work is done for a duration of one semsester. A problem is identified in the field of electronics and communication engineering and their objectives are defined. A literature survey is done to understand the current state-of-the-art and identify gap areas. Then a detailed plan of execution is done to design/implement/develop the problem solution.

The project can be done under faculty of IIST, ISRO centers or in other industries/institutes with project oppurtunities. The project is evaluated in two phases with a midterm review and final evaluation. At the end of the project a report has to be submitted.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Apply fundamental principles and theories of electronics and communication engineering.
CO2	Utilize simulation tools and software to model and analyze the real word engineering problems
CO3	Analyze the performance of the developed system/prototype/solution using appropriate performance metrics.
CO4	Design and implement innovative solutions or improvements to existing state-of-the-art techniques
CO5	Create novel approaches/applications/solutions to real word engineering problems

DEPARTMENT ELECTIVE COURSES

Sr. No	CourseCode	CourseName
1	AV461	Advanced Control Theory
2	AV462	Embedded Systems and Real Time OS
3	AV463	Soft Computing
4	AV464	Advanced DSP and Adaptive Filter
5	AV465	Robust and Optimal Control
6	AV466	Estimation and Stochastic Theory
7	AV467	Introduction to Optimization and OR
8	AV468	Digital Control System
9	AV469	EMI/ EMC
10	AV470	Digital Image Processing
11	AV471	VLSI Design
12	AV472	Opto-Electronics and Fiber Optics Communication
13	AV473	Information Theory and Coding
14	AV474	Cryptography
15	AV475	Mobile Communication
16	AV476	Microwave Integrated Circuits
17	AV477	Radar Systems
18	AV478	Operating Systems
19	AV479	Computer Graphics
20	AV480	Graph Theory and OR
21	AV481	Modern Algebra and Tensors
22	AV482	Data Structure and DBMS
23	AV483	Software Engineering
24	AV484	Wireless Mesh Network
25	AV485	Microelectronics and Microsystems
26	AV486	Antenna Theory and Design
27	AV487	Virtual Reality
28	AV488	Guidance System
29	AV489	Pattern Recognition and Machine Learning
30	AV490	Deep Learning for Computational Data Science
31	AV491	Advanced Sensors and Interface Electronics
32	AV492	Control of Electric Drives
33	AV493	Machine Learning for Signal Processing
34	AV494	Image and Video Processing
35	AV495	Modeling of Launch Vehicle and Space Craft Dynamics
36	AV496	Satellite communication
37	AV497	Complex Networks
38	AV498	Introduction to Computer Vision
39	AV499	Applied Markov Decision Processes an Reinforcement Learning
40	AV500	Modelling and Control of Robotic Systems

41	AV501	Power Electronics
42	AV502	Satellite and Optical Communication
43	AV503	Navigation System and Sensor
44	AV504	Embedded Systems and Applications
45	AV505	Robotics and Control :Theory and Practice (SwayamCourse)

Note: All PG courses in all disciplines (Digital Signal Processing, RF and Microwave, Control Systems, Power Electronics, and VLSI and Microsystems) will also be offered as approved electives, based on the areas of interest.

ELECTIVE COURSES

AV461 ADVANCED CONTROL THEORY (3-0-0) 3 Credits

State space Approach: State space modeling of physical systems – diagonal and Jordan canonical forms – Solution of Linear Time Invariant (LTI) state equation – Cayley Hamilton theorem – Controllability and Observability Tests – Kalman decomposition technique – Controller design by state feedback – Full order/reduced order observer design – observer-based state feedback control – stability definitions in state space domain.

Adaptive control theory: System Identification – Frequency – Impulse – Step Response methods – Off-line – on line methods – Least square – Recursive least square – fixed memory – stochastic approximate method. MRAS & STC: The gradient approach – MIT rule Liapunov Functions – Pole placement control – minimum variance control – Predictive control.

Text Books:

1. Karl.J.Astrom, Bjorn Witten Mark, Adaptive Control, 2nd Ed., Pearson Education Pvt. Ltd.
2. M.Gopal, 'Digital Control Systems and State Space Method', 3rd Ed., TMH, 2008.

References:

1. Katsuhiko Ogata, 'Modern Control Engineering', PHI -India, New Delhi 1989.
2. Fairman, 'Linear Control Theory: State Space Approach', John Wiley, 1998.
3. John S. Bay, 'Fundamentals of Linear State Space Systems', McGraw Hill, 1998.
4. Isermann R, 'Digital Control System vol. I & II', Narosa Publishing House, Reprint 1993.
5. Mendal JM, 'Discrete Technique of Parameter Estimate', Marcel Dekkas, New York, 1973.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Ability to Understanding the basics of state-space modelling which includes representation and solution to state space, physical significance of Eigenvalues and Eigenvectors
CO2	Analyze the controllability and observability with applications
CO3	Understanding the basics of adaptive Control and Various identification algorithms
CO4	Develop skills to design and analyse the Model Reference Adaptive Control and Self tuned Regulator

AV462 EMBEDDED SYSTEMS AND REAL TIME OS (3-0-0) 3 Credits

Review of Embedded Hardware: Gates - Timing Diagram - Memory – microprocessors. Interrupts Microprocessor Architecture - Interrupt Basics - Shared Data Problem - Interrupt latency. Software Development: Round-Robin, Round robin with Interrupts, function-Queue- Scheduling Architecture, Algorithms. Introduction to - Assembler - Compiler - Cross Compilers and Integrated Development Environment (IDE). Object-Oriented Interfacing, Recursion, Debugging strategies, Simulators. Embedded Microcomputer Systems - Motorola MC68H11: Motorola MC68H11 Family Architecture, Interfacing methods. Microchip PIC Microcontroller: Introduction, CPU Architecture - Registers - Instruction sets addressing modes - Loop timing - Timers - Interrupts, Interrupt timing, I/O Expansion, I2C Bus Operation Serial EEPROM, Analog to Digital converter, UART - Baud Rate - Data Handling - Initialization, Special Features - Serial Programming - Parallel Slave Port.

Real-Time Operating Systems: Task and Task States, Tasks and data, Semaphores and shared Data Operating system Services - Message queues - Timer function - Events - Memory Management, Interrupt Routines in an RTOS environment, Basic design using RTOS.

Text Books/References:

1. Wayne Wolf, Computers as Components - Principles of Embedded Computer System Design, Morgan Kaufmann Publisher, 2006.
2. David E. Simon, An Embedded Software Primer, Pearson Education, 2007.
3. K.V.K.K. Prasad, Embedded Real-Time Systems: Concepts, Design & Programming, Dreamtech Press, 2005.
4. Tim Wilmshurst, An Introduction to the Design of Small Scale Embedded Systems, Palgrave Publisher, 2004.
5. Sriram V. Iyer, Pankaj Gupta, Embedded Real Time Systems Programming, Tata McGraw Hill, 2004.
6. Tammy Noergaard, Embedded Systems Architecture, Elsevier, 2006.

AV463	SOFT COMPUTING	(3-0-0) 3 Credits

Introduction of Soft-computing tools - Neural Networks, Fuzzy Logic, Genetic Algorithm, and Probabilistic Reasoning; Neural network approaches in engineering analysis, design, and diagnostics problems; Applications of Fuzzy Logic concepts in Engineering Problems; Engineering optimization problem-solving using genetic algorithm; applications of probabilistic reasoning approaches.

Text Books / References:

1. S. Rajasekaran and G.A. Vijaylakshmi Pai. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.
2. K.H. Lee. First Course on Fuzzy Theory and Applications, Springer-Verlag.
3. J. Yen and R. Langari. Fuzzy Logic, Intelligence, Control and Information, Pearson Education.

AV464 ADVANCED DSP AND ADAPTIVE FILTER (3-0-0) 3 Credits

Discrete Random Process: Expectation, Variance and Co-variance, Uniform, Gaussian and Exponentially distributed noise, Hillbert space and inner product for discrete signals, Energy of discrete signals, Parseval’s theorem, Wiener Khintchine relation, power spectral density, Sum decomposition theorem, Spectral factorization theorem.

Spectrum Estimation: periodogram, Non – parametric methods of spectral estimation Correlation method, WELCH method – AR, MA, ARMA models. Tule – Walker method. Linear Estimation and Prediction: ML estimate – Efficiency of estimator, Cramer Rao bound - LMS criterion. Wiener filter – Recursive estimator – Kalman estimator – Linear prediction, Analysis and synthesis filters, Levinson resursion, Lattice realization. Adaptive filters: FIR adaptive filter – Newton’s Steepest descent algorithm – Widrow Hoff LMS adaptation algorithms – Adaptive noise cancellation, Adaptive equalizer, Adaptive echo cancellors.

Text Books /References:

1. M. Hays: Statistical Digital Signal Processing and Modelling, John Willey and Sons, 1996.
2. Simon Haykin: Adaptive Filter Theory, Prentice Hall, 1996
3. "Adaptive Filters: Theory and Applications", by B. Farhang-Boroujeny, John Wiley and Sons, 1999.
4. John G Proakis and Manolakis, “ Digital Signal Processing Principles, Algorithms andApplications”, Pearson, Fourth Edition, 2007.
5. Sophocles J. Orfanidis, Optimum Signal Processing, An Introduction, McGraw Hill,1990.

AV465 ROBUST AND OPTIMUM CONTROL (3-0-0) 3 Credits

Signals and systems, Vector space, Norms, Matrix theory: Inversion formula, Schur's complement, Singular Value Decomposition, Positive definiteness; Linear Matrix Inequality: Affine function, Convexity, Elimination lemma, S-procedure; Calculus of variation, Euler's Theorem, Lagrange multiplier. Linear fractional transformation (LFT), Different uncertainty structures: Additive, Multiplicative, Uncertainty in Coprime factors; Concept of loop shaping, Bode's Gain and phase relationship, Small Gain theorem. LQR, LQG, Hamiltonian matrix, Riccati equation, H-infinity control, H-infinity Controller design via DGKF and LMI techniques, H-infinity loop shaping technique, Structured singular value (mu) synthesis, Design examples.

Text Books/References:

1. D.S.Naidu, Optimal Control Systems, CRC Press
2. Sinha, Linear Systems Optimal and Robust Control, CRC Press
3. D.E.Kirk, Optimal Control Theory An Introduction, PHI.
4. K.Morris, Introduction to Feedback Control, Academic Press.
5. Helton, Merino, Classical Control using $H\infty$ Methods, 1/e, SIAM Publications
6. Ozbay, Introduction to Feedback Control Theory, CRC Press
7. Gu, Petkov, Konstantinov, Robust Control Design with MATLAB, Springer India
8. Qiu, Zhou, Introduction to Feedback Control, Prentice Hall, 2009.

AV466 ESTIMATION AND STOCHASTIC THEORY (3-0-0) 3 Credits

Elements of probability theory - random variables - Gaussian distribution - stochastic processes characterizations and properties - Gauss-Markov processes - Brownian motion process - Gauss-Markov models - Optimal estimation for discrete-time systems - fundamental theorem of estimation - optimal prediction.

Optimal filtering - Weiner approach - continuous-time Kalman Filter - properties and implementation - steady-state Kalman Filter - discrete-time Kalman Filter - implementation – sub optimal steady-state Kalman Filter - Extended Kalman Filter - practical applications.

Optimal smoothing - Optimal fixed-interval smoothing - optimal fixed-point smoothing - optimal fixed-lag smoothing - stability - performance evaluation.

TextBooks/References:

1. M.D. Srinath, P.K. Rajasekaran and R. Viswanathan: Statistical Signal Processing with Applications, PHI, 1996.
2. D.G. Manolakis, V.K. Ingle and S.M. Kogon: Statistical and Adaptive Signal Processing, McGraw Hill, 2000.
3. S. M. Kay: Modern Spectral Estimation, Prentice Hall, 1987.
4. H. V. Poor, "An Introduction to Signal Detection and Estimation", Springer, 2/e, 1998.
5. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 1993.
6. M.S. Grewal, A.P. Andrews, “Kalmanfiltering : Theory and Practice”, Second edition, John Wiley & Sons, 2001.
7. C.K. Chui, G. Chen, “Kalman Filtering with Real-Time Applications”, Third edition, Springer-Verlag, 1999.
8. R.G. Brown, Y.C. Hwang, “Introduction to Random Signals and Applied Kalman Filtering”, Second edition, John Wiley & Sons, 1992.

AV467 INTRODUCTION TO OPTIMIZATION AND OR (3-0-0) 3 Credits

Vector spaces and matrices, transformations, eigenvalues and eigenvectors, norms; geometrical concepts -- hyperplanes, convex sets, polytopes and polyhedra; unconstrained optimization - condition for local minima; one dimensional search methods -- golden section, fibonacci, newtons, secant search methods; gradient methods -- steepest descent; newton's method, conjugate direction methods, conjugate gradient method; constrained optimization -- equality conditions, lagrange condition, second order conditions; inequality constraints -- karush-kuhntucker condition; convex optimization; introduction to assignment problem, decision analysis dynamic programming and linear programming.

Text Books/References:

1. An Introduction to Optimization, Edwin K. P. Chong and Stanislaw H. zak, Wiley Interscience, 2008.
2. D. G. Luenberger, Optimization by vector space methods, New York, Wiley, 1969.
3. Convex Optimization Theory, D. P. Bertsekas, Athena Scientific optimization and computation series, 2009
4. Introduction to Operations Research, rederick S. Hillier, Gerald J. Lieberman, McGraw-Hill, 2010

AV468 DIGITAL CONTROL SYSTEM (3-0-0) 3 Credits

Digital control systems – sample and hold systems - Jury stability criterion – Implementation of digital controllers – tunable PID controllers – Digital compensator design using root locus and frequency response methods.

Linear versus nonlinear systems - Describing function analysis - common nonlinearities - Analysis of non-linear systems using phase plane technique - condition for stability - Stability in the sense of Lyapunov and absolute stability - Popov's stability criterion - Lure's Transformation. Nonlinear control system design problem - Concept of variable - structure controller and sliding control.

Text Books:

1. M.Gopal, 'Digital Control and State variable methods: Conventional and Intelligentcontrol systems', Tata McGraw Hill, 3rd Ed., 2009.

References:

1. H. K. Khalil, 'Nonlinear Systems', Prentice Hall, 3rd Ed., 2002.
2. S.Sastry, 'Nonlinear Systems: Analysis, Stability and Control', Springer, 1999.
3. Nijmeijer, Henk, Schaft, Arjan van der, 'Nonlinear Dynamical Control Systems', Springer, 1990.
4. Graham, McRuer, Analysis of Nonlinear Control Systems.

AV469 **EMI/EMC** **(3-0-0) 3 Credits**

Aspects of EMC with examples, Common EMC units, EMC requirements for electronic systems, Radiated emissions, Conducted emissions, ESD. Application of EMC design, Wires, PCB lands, Component leads, resistors, capacitors, inductors, and ferrites. Electromechanical devices, Digital circuit devices. Mechanical switches (as suppression), Simple emission models for wires and PCB lands, Lice impedance stabilization network (LISN) , Power supply filters. Power supplies including SMPS. Three conductor lines and crosstalk, Shielded wires, Twisted wires, Multiconductor lines and effects of incident fields, Shielding, Origin effects, prevention of ESD event, its hardware and immunity. System design for EMC, Grounding, System configuration, PCB design.

Text Books/References:

1. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol. 5, EMI Prediction and Analysis Technique – 1972.
2. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand, 1996.
3. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.
4. Kaiser B. E., "Principles of Electromagnetic Compatibility", Artech House, 1987.

AV470 DIGITAL IMAGE PROCESSING (3-0-0) 3 Credits

Digital Image Fundamentals**:** Elements of visual perception – Image sampling and quantization Basic relationship between pixels – Basic geometric transformations. Image fundamentals and image restoration: Spatial Domain methods-Spatial filtering:- Frequency domain filters – Model of Image Degradation/restoration process – Noise models – Inverse filtering -Least mean square filtering – Constrained least mean square filtering – Blind image restoration – Pseudo inverse – Singular value decomposition.

Multi-resolution Analysis and Compression**:** Multi Resolution Analysis: Image Pyramids – Multi resolution expansion – Wavelet Transforms. Image compression: Fundamentals Elements of Information Theory – Error free compression – Lossy Compression – Compression Standards. Wavelet coding – Basics of Image compression standards: JPEG, MPEG, Basics of Vector quantization.

Image Segmentation and Image Analysis**:** Edge detection – Thresholding - Region Based segmentation – Boundary representation: boundary descriptors: Texture, Motion image analysis. Color Image Processing – Color Models – Color Image enhancement-Segmentation Object Recognition and Image Understanding: Patterns and pattern classes - Decision-Theoretic methods - Structural methods-3D Vision.

Text Books:

1. Rafael C Gonzalez, Richard E Woods 2nd Edition, Digital Image Processing - Pearson Education 2009.

References:

1. William K Pratt, Digital Image Processing John Willey, 2001.
2. MillmanSonka, Vaclav hlavac, Roger Boyle, Broos/colic, Image Processing Analysis and Machine Vision –, Thompson Learniy, 1999.
3. A.K. Jain, Fundamentals of Digital Image Processing, PHI, New Delhi, 1995.
4. Chanda Dutta Magundar , Digital Image Processing and Applications, Prentice Hall of India, 2000.

AV471	VLSI DESIGN	(3-0-0) 3 Credits

Introduction, Manufacturing process: CMOS integrated circuits, Device Physics: MOSFET, CMOS inverter: Characteristics, Static and Dynamic Logic Gates, Sequential logic Gates, Implementation for Digital ICs. Timing Issues in Digital Circuits, Designing Memory and Array Structures.

Text Books:

1. Jan M Rabaey, AnanthaChandrakasan, Borivoje Nikolic, Digital Integrated Circuits, Prentice Hall, 2002.

References:

1. Pucknell, Basic VLSI Design, Prentice Hall, 2008.
2. Fabricius, Eugene D, Introduction to VLSI Design, McGraw-Hill, 1990.
3. Neil H E Weste, Kamran Eshraghian, Principles of CMOS VLSI Design, A system perspective, Addison-Wesley, 1985.
4. R Jacob Baker ,Harry, David E, CMOS Circuit Design, Layout, and Simulation, Willy, 2011.

AV472	OPTO-ELECTRONICS AND FIBER OPTICS COMMUNICATION	(3-0-0) 3 Credits

Review of P-N junction characteristics – semiconductor-heterojunction-LEDs (spontaneous emission-LED structure-surface emitting-Edge emitting-Injection efficiency-recombination efficiency-LED characteristics-spectral response-modulation-Bandwidth. Laser diodes-Basic principle-condition for gain-Laser action-population inversion-stimulated emission-Injection faster diode-structure temperature effects-modulation-comparison between LED and ILDs. Optical detectors principle-absorption coefficient-detector characteristics-Quantum efficiency-responsivity-response time-bias voltage-Noise in detectors P-N junction-photo diode-B.W-Noise-photo transistor.

Optical Fiber-structure-propagation-wave equation-phase and group velocity-transmission characteristics-attenuation-absorption-scattering losses-dispersion-fiber bend losses-source coupling, splices and connectors-wavelength division multiplexing. Optical fiber system-system design consideration-fiber-source limitations-pre-amplifier-equalization-Fiber optic link analysis-typical link design.

Text Books:

1. Gerd Keiser, Optical Fiber Communications, 3rd Edition, McGraw Hill Publications, 2000.

References:

1. Pallab Bhattacharya, Semiconductor Opto electronics Devices, Pearson Education
2. John M Senior Optical fibre Communication Systems-Principles and practice, PHI.
3. John Gower, Optical communication Systems, PHI.

Course Outcomes:

Course Outcomes	Statements
CO1	Understand the electronic and optoelectronic properties of semiconductors, operation of PN diode, various light absorption and emission mechanisms in semiconductors
CO2	Study the basic operating principle of LED, semiconductor lasers, heterojunction lasers, quantum well lasers, VCSEL, DFB and DBR lasers, photodetectors, solar cells.
CO3	Understand total internal reflection, Snell's law, understanding construction and light guiding mechanisms in waveguides [optical fibers and planar waveguides].
CO4	Design an optical communication link and test it and understand different types of optical fibres, loss and dispersion mechanisms.

AV473	INFORMATION THEORY AND CODING	(3-0-0) 3 Credits

Sources – memory less and Markov; Information; Entropy; Extended sources; Shannon’s noiseless coding theorem; Source coding; Mutual information; Channel capacity; BSC and other channels; Shannon's channel capacity theorem; Continuous channels; Comparison of communication systems based on Information Theory; Channel Coding - block and convolutional. Block codes majority logic decoding; Viterbi decoding algorithm; Coding gains and performance.

TextBooks /References:

1. Shu Lin & Daniel J. Costello.Jr., Error Control Coding : Fundamentals and Applications, Prentice Hall Inc., Englewood Cliffs, NJ.
2. Thomas M. Cover, Joy A. Thomas, Elements of Information theory, 2nd ed., John Wiley & Sons Pvt. Ltd.
3. Simon Haykin. Communication Systems, 3rd ed., John Wiley & Sons Pvt. Ltd.
4. Taub & Schilling. Principles of Communication Systems, 2nd ed., Tata McGraw Hill, New Delhi.
5. Das, Mullick & Chatterjee. Principles of Digital Communication, Wiley Eastern Ltd.
6. The theory of error-correcting codes by F. J. MacWilliams and N. J. A. Sloane (North- Holland publishers).
7. Algebraic codes for data transmission by Richard Blahut (Cambridge).

Course Outcomes:

Course Outcomes	Statements
CO1	Understand the theoretical bounds and the limitation of communication system
CO2	Design lossless and lossy source coding techniques
CO3	Ability to design a channel coding scheme for the specific error correction capability of the communication system

AV474 **CRYPTOGRAPHY** **(3-0-0) 3 Credits**

Introduction to number theory – Symmetric key and Public key crypto systems which includes pseudorandom functions and permutations, block ciphers, symmetric encryption schemes, security of symmetric encryption schemes, hash functions, message authentication codes (MACs), security of MACs, PKI, public-key(asymmetric) encryption, digital signatures, security of asymmetric encryption and digital signature scheme. Chaos base cryptography systems – quantum computing – introduction to smartcard technology.

Text Books/References:

1. William Stallings, "Cryptography And Network Security – Principles and Practices", Pearson Education, Third Edition, 2003.
2. Behrouz A. Foruzan, "Cryptography and Network Security", Tata McGraw-Hill, 2007
3. Bruce Schneier, "Applied Cryptography", John Wiley & Sons Inc, 2001.
4. Wade Trappe and Lawrence C. Washington , " Introduction to Cryptography with coding theory" , Pearson Education, 2007.
5. Wenbo Mao, " Modern Cryptography Theory and Practice" , Pearson Education, 2007.
6. Thomas Calabrese, "Information Security Intelligence: Cryptographic Principles and Applications", Thomson Delmar Learning, 2006.

AV475	MOBILE COMMUNICATION	(3-0-0) 3 Credits

Cellular Concept**:** Frequency Reuse, Channel Assignment, Hand Off, Interference and System Capacity, Tracking And Grade Of Service, Improving Coverage and Capacity In Cellular Systems. Mobile Radio Propagation**:** Free Space Propagation Model, Outdoor Propagation Models, Indoor Propagation Models, Small Scale Multipath Propagation, Impulse Model, Small Scale Multipath Measurements, Parameters Of Mobile Multipath Channels, Types Of Small Scale Fading, Statistical Models For Multipath Fading Channels.

Modulation Techniques**:** Minimum Shift Keying, Gaussian MSK, M-ARY QAM, M-ARY FSK, Orthogonal Frequency Division Multiplexing, Performance of Digital Modulation In Slow-Flat Fading Channels And Frequency Selective Mobile Channels. Equalization: Survey of Equalization Techniques, Linear Equalization, Non-Linear Equalization, Algorithms for Adaptive Equalization. Diversity Techniques, Rake Receiver.

Coding: Vocoders, Linear Predictive Coders, Selection of Speech Coders for Mobile Communication, GSM Codec and RS Codes for CDPD.

Multiple Access Techniques**:** FDMA, TDMA, CDMA, SDMA, Capacity of Cellular CDMA and SDMA.

Wireless Systems and Standards**:** Second Generation and Third Generation Wireless Networks and Standards, WLL, Blue Tooth. AMPS, GSM, IS-95 and DECT

Text Books:

1. T. Rappaport, "Wireless Communication: Principles and Practice", Prentice Hall PTR

References:

1. Palanivelu, T. G. ,Nakkeeran, R, "Wireless And Mobile Communication", PHI.
2. Stüber, Gordon L.," Principles of Mobile Communication**"** 2nd ed., Springer publications.

AV476 MICROWAVE INTEGRATED CIRCUITS (3-0-0) 3 Credits

Introduction to microwave integrated circuits: Active and passive components. Analysis of microstrip lines: variational method, conformal transformation, numerical analysis; losses in microstrip lines; Slot line and Coupled lines; Design of power dividers and combiners, directional couplers, hybrid couplers, filters. Microstrip lines on ferrite and garnet substrates; Isolators and circulators; Lumped elements in MICs. Technology of MICs: Monolithic and hybrid substrates; thin and thick film technologies, computer aided design.

Text Books/References:

1. Davis W. Alan, Van, Microwave Semiconductor Circuit Design, Nostrand, Reinhold, 1984.
2. Gonzalez G., Microwave Transistor Amplifier: Analysis and Design, Prentice Hall 1984.
3. Samuel Y. Liao, Microwave Circuit Analysis and Amplifier Design, Prentice Hall 1987.
4. Ralph S. Carson, High Frequency Amplifier, Wiley Interscience, 1982.

AV477	RADAR SYSTEMS	(3-0-0) 3 Credits

Nature of Radar and Applications, Simple form of Radar Equation, Radar Block Diagram and Operation, Prediction of Range Performance, Minimum Detectable Signal, Radar Receivers, Transmitter Power, CW and Frequency Modulated Radar, MTI and Pulse Doppler Radar, Tracking Radar, Detection of Radar Signals in Noise, Airborne Radar, Space borne Radar, Synthesis aperture radar, SHAR and MST radar.

Text Books/References:

1. M.I. Skolnik, Introduction to Radar Systems, McGraw hill, 2000.
2. M.I. Skolnik, Radar Handbook, McGraw hill, 2nd edition, 1990.
3. A.K. Sen and A.B. Battacharya, Radar Systems and Radar Aids to Naviation, Khanna Publications, 1988.

AV478	OPERATING SYSTEMS	(3-0-0) 3 Credits

Overview: functions of Operating systems, layered architecture; basic concept; interrupt architecture, system calls and notion of a process and threads; synchronization and protection issues; scheduling; memory management including virtual memory management including virtual memory and paging techniques; i/o architecture and device management; file systems; distributed file systems; Case studies of Unix , Windows NT.

Text Books/References:

1. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne Operating System Concepts, 7th Edition, Wiley publications, 2005.
2. Tanenbaum A.S., Operating systems:Design and implementation, Prentice Hall, 1992.
3. Stallings W, Operating systems, second edition, prentice Hall, 1995.

AV479	COMPUTER GRAPHICS	(3-0-0) 3 Credits

Graphics hardware and display devices; graphics primitives- drawing lines and curves; 2D and 3D transformations; segments and their applications; generating curves, surfaces and volumes in 3D, wire-frame models, Bezier and spline curves and surfaces; geometric modeling- elementary geometric algorithms for polygons, boundary representations, constructive solid geometry, spatial data structures; hidden surface and line elimination; rendering- shading, light models, realistic image synthesis techniques, textures and image-based rendering; video games and computer animation.

Text Books/References:

1. Foley, van Dam, Feiner and Hughes, Computer Graphics (Principles and Practice), Addisen Wesley.
2. D Hearn and P M Baker, Computer Graphics, Printice Hall of India.
3. D F Rogers, Mathematical Elements for Computer Graphics, McGraw Hill.
4. D F Rogers, Procedural Elements for Computer Graphics, McGraw Hill.
5. Edward Angele, Interactive Computer Graphics, A top-down approach with OpenGL, Addisen Wesley.
6. G Farin, Curves and Surfaces for Computer Aided Geometric Design, Academic Press.

AV480 GRAPH THEORY AND OR (3-0-0) 3 Credits

Graphs paths and circuits, trees and fundamental circuits, cut-sets and cut-vertices, planar and dual graphs, vector spaces of graphs, matrix representation of graphs; transport networks, maximal flow, linear programming, minimal cut, maxflow-mincut theorem, minimal-cost flows, multicommodity flow, activity network, game theory.

TextBooks/References:

1. Narsingh Deo, Graph Theory With Applications To Engineering And Computer Science, PHI, India, 1974.
2. T. B. Boffey, Graph theory in operations research, Macmillan, 1982

AV481 MODERN ALGEBRA AND TENSORS (3-0-0) 3 Credits

Sets, groups, fields, rings, isomorphisms, vector spaces, modules; vectors and tensors in a finite dimensional space, vector and tensor analysis in euclidean space, curves and surfaces in three dimensional euclidean space, eigen value problem and spectral decomposition of second-order tensors, fourth order-tensors.

Text Books/References:

1. William J. Gilbert, W. Keith Nicholson, Modern Algebra with Applications, John Wiley and Sons, 2004.
2. Mikhail Itskov, Tensor Algebra and Tensor Analysis for Engineers, Springer, 2008.

AV482 **DATA STRUCTURE AND DBMS** **(3-0-0) 3 Credits**

Review of basic data structures and their realization in an object-oriented environment. The following topics will be covered with emphasis on formal analysis and design: Dynamic Data structures; 2-3 trees, Red-black trees, binary heaps, binomial and Fibonacci heaps, Skip lists, universal hashing. Data structures for maintaining ranges, intervals, and disjoint sets with applications. Basic algorithmic techniques like dynamic programming and divide-and-conquer. Sorting algorithms with analysis, integer sorting algorithms with analysis, integer selection. Graph algorithms like DFS with applications, MSTs, and shortest paths.

Database System Architecture - Data Abstraction, Data Independence, Data Definition, and Data Manipulation Languages. Data Models - Entity-Relationship, Network, Relational, and Object-Oriented Data Models, Integrity Constraints, and Data Manipulation Operations. Relational Query Languages: Relational Algebra, Tuple and Domain Relational Calculus, SQL, and QBE. Relational Database Design: Domain and Data dependency, Armstrong's Axioms, Normal Forms, Dependency Preservation, Lossless design. Query Processing and Optimization: Evaluation of Relational Algebra Expressions, Query Equivalence, Join strategies, Query Optimization Algorithms. Storage Strategies: Indices, B-trees, Hashing; Transaction Processing: Recovery and Concurrency Control, Locking and Timestamp-based Schedulers, Multiversion and Optimistic Concurrency Control schemes. Advanced Topics: Object-oriented and Object Relational Databases, Logical Databases, Web Databases, Distributed Databases, Data Warehouse, and Data Mining.

TextBooks/References:

1. Gregory L. Heileman , Data Structure, Algorithm and OOP, Tata Mc Graw Hill, NewDelhi.
2. Adam Drozdek, Data Structures & Algorithm in C++,Vikas publication House.
3. Silberschatz, H. Korth, Database System Concepts, 5th Edition, McGraw-Hill.
4. Raghu Ramakrishnan, Database Management Systems, Johannes Gehrke 4th Edition, McGraw-Hill

AV483	SOFTWARE ENGINEERING	(3-0-0) 3 Credits

S/W life cycle; problem of S/W production and the need for S/W engineering; Concepts and techniques relevant to production of large software systems: Structured programming, top down design and development, information hiding; strength, coupling and complexity measures; procedural, data, and control abstraction; specifications; organization and management of large software design projects; program libraries; documentation, design methods and testing; several programming projects of varying size undertaken by students working singly and in groups using software specification tools, S/W project management; parameter for cost estimation.

Text Books /References:

1. Roger Pressman.S., Software Engineering: A Practitioner's Approach, (3rd Edition), McGraw Hill, 1997.
2. I Sommerville, Software Engineering V edition: , 9th ed, Addison Wesley, 1996.
3. P fleeger, Software Engineering, Prentice Hall, 1999.
4. Carlo Ghezzi, Mehdi Jazayari, Dino Mandrioli, Fundamental of Software Engineering, Prentice Hall of India 1991.

AV484	WIRELESS MESH NETWORK	(3-0-0) 3 Credits

Introduction and overview of Wireless Mesh Networks, Evolution of Wireless Mesh Networks, Architectural issues in Wireless Mesh Networks, Capacity of Wireless Mesh Networks, Layerwise Protocol design issues in Wireless Mesh Networks, MAC layer protocols for Wireless Mesh Networks, Network layer protocols for Wireless Mesh Networks, Transport layer protocols for Wireless Mesh Networks, Load Balancing in Wireless Mesh Networks, Wide Area Wireless Mesh Networks, Design issues for Wide Area Wireless Mesh Networks, Resource allocation problems in Wireless Mesh Networks, Hybrid wireless mesh networks including WiMAX networks, and Layer-wise open research problems on protocol design for Wireless Mesh Networks.

TextBooks /References:

1. Yan Zhang, Jijun Luo, and Honglin Hu, Wireless Mesh Networking: Architectures, Protocols and Standards, Auerbach Publications, December 2006.
2. Ian Akyildiz and Xudong Wang, Wireless Mesh Networks, John Wiley and Sons, March 2009.
3. C. Siva Ram Murthy and B. S. Manoj, Ad hoc Wireless Networks: Architectures and Protocols, Prentice-Hall PTR, New Jersey, May 2004.

AV485	MICROELECTRONICS AND MICROSYSTEMS	(3-0-0) 3 Credits

This course provides basic understanding on the design, fabrication and system development aspects of microelectronics/microsystems. This enables to understand and apply common principles of sensing and actuation at micro/nanoscale. The course also gives a broad perspective of application areas and commercialization aspects of MEMS and microsystems.

Topics:

- Sensing and actuation principles of Microsystems
- Introduction to Microsystems Design
- Electromechanical Transduction in MEMS
- Microelectronics technologies for MEMS and Micromachining
    - Dopant diffusion & Ion-implantation in Silicon
    - Thin film deposition and growth (Specific to MEMS)
    - Lithography: Single Side and Double Side Lithography
    - Etching/micromachining
    - Polymer MEMS
- Foundry MEMS processes
- Microelectronics-Microsystems Integration
- Bonding & Packaging of MEMS
- MEMS Micro sensors, Actuators, Applications & Case studies
    - MEMS Inertial Sensors, Pressure Sensors, Temperature Sensor, Environmental Sensors.
    - Case studies: Design + Materials + Microsystem Technology + Application

Text Books /References:

1. Chang Liu, Foundations of MEMS, Pearson Education, 2011.
2. S. D. Senturia, Microsystem Design, Springer, 2005.
3. James D Plummer, Michael D Deal, Peter B. Griffin, Silicon VLSI Technology- Fundamentals, Practice And Modeling, Pearson (2009)
4. G. K. Ananthasuresh , K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat , V. K. Aatre Micro and Smart Systems, Wiley.
5. MinhangBao "Analysis and Design Principles of MEMS Devicess", Elsevier B.V, 2009.
6. MarcMadau, Fundamentals of Microfabrication Science of Miniaturization, CRC Press.

Course Outcomes

Course Outcomes	Statement
CO1	Understand and apply common principles of sensing and actuation at micro/nanoscale
CO2	Understand fundamental concepts on the design and analysis of electromechanical behavior of MEMS and Microsystems
CO3	Attains familiarity on the materials and good understanding on the fabrication processes for realization of microsystems
CO4	Gains a broad perspective on the application areas of Microsystems and integrated CMOS-MEMS systems and develops ability to develop Microsystems based sensors and systems for practical applications

AV486 ANTENNA THEORY AND DESIGN (3-0-0) 3 Credits

Antenna Fundamentals–Basic Radiation Mechanism, Common Types of Antennas, Antenna Parameters – Impedance, Bandwidth, Directivity, Gain, Efficiency, Beamwidth, Polarization and Efficiency, Equivalent Circuit of Antennas, Antenna in receiving mode, basic concept of circular polarization, axial ratio, polarization loss factor.

Wire Antennas- Radiation Integrals and Auxiliary Potential Functions, Solutions of the Inhomogeneous Vector Potential Wave Equation, Linear Wire Antennas: Field analysis of the ideal Dipole, Electrically Short or Small Dipoles , The Half-Wave Dipole, Calculation of radiation resistance, gain, directivity, HPBW for various cases, The Dipole of Arbitrary Length , Antennas on or Near PEC Ground Planes, concept of monopole antenna, Loop Antenna: analysis of small circular loop, Radiation resistance, radiation pattern, radiation intensity and directivity.

Antenna Arrays– Fundamentals of Antenna Arrays , basic analysis and pattern of two element array, N-element linear array, Graphical Method for Developing the Radiation Pattern, broadside and end fire array, Pattern Multiplication Theorem, Half-Power Beam Width (HPBW), Directivity, Side Lobe Level (SLL) , Even Element Linear Array with Uniform Spacing and Nonuniform Excitation - Directivity for Binomial Arrays, Basic concept of Planar Arrays -Mutual Impedance and Driving Point impedance of Antenna Arrays, Yagi-Uda Antennas, Log Period Antenna.

Broadband Antenna- Different techniques of bandwidth enhancements, biconical antenna, Travelling wave antennas, Helical antenna, Folded dipole Antenna, fundamental concept of UWB Antennas.

Microstrip Antennas**-** Basic characteristics, feeding methods, methods of analysis- transmission line and cavity model analysis, design of rectangular and circular patch antennas, quality factor, bandwidth and efficiency, design for circularly polarization, bandwidth and gain enhancement techniques.

Fundamentals of Horn and Reflector Antenna
Fundamentals of Antenna Measurements

TextBooks/References:

1. Constantine A. Balanis, Antenna Theory, Analysis and Design, Second edition, JohnWilley and Son, Inc.
2. Warren L. Stutzman, Gary A. Thiele, Antenna Theory and Design, 2nd Edition, JohnWilley and Son, Inc.

Course Outcomes

Course Outcomes	Statement
CO1	Learning the basics concepts of antenna and its various characteristics.
CO2	Analysis and design of various fundamental radiating structures and their mathematical background

CO3	Understanding the fundamentals of array antenna and its application in Beam shaping.
CO4	Analyzing the design methods of broadband and multiband antennas.
CO5	Designing the state of art standard gain/ high gain antennas
CO6	Understanding the antenna measurement fundamentals

AV487	VIRTUAL REALITY	(3-0-0) 3 Credits

Introduction: What is VR, applications, basic components of VR, Success stories of VR and challenges, VR hardware, visualization, VR content generation and storing?

Human Senses and VR: Discussion on how human senses correlates to VR such as Visual system, Auditory System, Olfaction, Gustation etc.

Three dimensional geometry theory: coordinate system, Vectors, Line, plane transformation etc.

The rendering pipeline: Geometry and vertex operations, culling and clipping, screen mapping, scan conversion or rasterization, fragment processing, texturing etc.

Image based rendering**:** General approaches to IBR, acquiring images for IBR, mosaicing, making panoramic images etc.

Computer vision in VR: The mathematical language of geometric computer vision, cameras, CV application in VR, Virtual Worlds using Computer Vision.

Stereopsis:parallax, HMD, active, passive and other stereoscopic systems etc

Navigation and Movement in VR: computer animation, moving and rotating in 3D, robotic motion, inverse kinematics etc

Laboratory: Introductory training in scripting and Vizard software demo on modeling. There will be lab exercises given to students for better understanding of the course.

Project**:** Projects will be given to students that need to be simulated using python/c/opengl/vrml/unity etc. The project will focus on creating a some interactive virtual world or some simulation based on physics etc. This project can either be done as individuals or in groups of two. Groups of two are responsible for clearly delineating each persons role in the project.

TextBooks/References:

1. A hitchhikers Guide to Virtual Reality, by Karen McMenemy, Stuart Ferguson.
2. Vizard Teacher in a Book from Vizard
3. IEEE conferences and Journals on Graphics, VR and computer vision.
4. Virtual Reality System by John Vince

AV488 GUIDANCE SYSTEM (3-0-0) 3 Credits

Fundamentals of guidance Basic results in interception and avoidance Taxonomy of guidance laws, command and booming guidance, classical guidance laws Comparative study of guidance laws from the point of view of time, missdistance, launch boundaries, control effort and implementation difficulties. Basic concepts of launch vehicle guidance, Explicit and Implicit guidance, Flat Earth guidance, Perturbation guidance, Velocity to be gained guidance concept, Delta guidance, Q guidance, Cross product steering, linear perturbation guidance, Open loop and Closed loop guidance.

Textbooks:

1. Katsuhiko Ogata, Modern Control Engineering, 4th Edition, Prentice Hall of India publishers, New Delhi, 2006.

References:

1. Gopal I and Nagrath N, Control systems, Wiley Eastern Ltd, New Delhi, 1985.
2. Norman S Nise, Control Systems Engineering, Wiley India, 4th edn, 2003
3. D'Azzo, Houpis, Feedback Control System Analysis and Synthesis, CRC Press, 2007
4. M.Gopal, Control systems, Principle and Design, Tata McGraw Hill publishing Co,m NewDelhi, 1997.
5. Kuo B.C., Automatic control systems, Prentice Hall India ltd, New Dehli, 1995.
6. Mutambara, Design and Analysis of Control Systems, CRC Press, 2008
7. Xue, Chen, Atherton, Linear Feedback Control Analysis and Design with MATLAB, SIAM Publications, 2006.
8. Qiu, Zhou, Introduction to Feedback Control, Prentice Hall, 2009.

AV489 PATTERN RECOGNITION AND MACHINE LEARNING (3-0-0) 3 Credits

PR overview- Feature extraction- Statistical Pattern Recognition- Supervised Learning- Parametric methods-Non parametric methods; ML estimation-Bayes estimation-k NN approaches. Dimensionality reduction, data normalization. Regression, and time series analysis. Linear discriminat functions. Fishers linear discriminant, linear perceptron and Neural Networks. Kernel methods and Support vector machine. Unsupervised learning and clustering. K-means and hierarchical clustering. Ensemble/ Adaboost classifier, Soft computing paradigms for classification and clustering. Applications to document analysis and recognition.

Text Books / References:

1. Pattern Classification (Pt.1) 2nd Edition by Richard O. Duda, Peter E. Hart, David G. Stork
2. "Pattern Recognition and Machine Learning", C.M. Bishop, 2nd Edition, Springer, 2011.
3. Sergios Theodoridis, "Machine Learning: A Bayesian and Optimization Perspective". Elsevier, 2015.

AV490 DEEP LEARNING FOR COMPUTATIONAL DATA SCIENCE (3-0-0) 3 Credits

Description: Deep learning methods are now prevalent in the area of machine learning, and are now used invariably in many research areas. In recent years it received significant media attention as well. The influx of research articles in this area demonstrates that these methods are remarkably successful at a diverse range of tasks. Namely self driving cars, new kinds of video games, AI, Automation, object detection and recognition, surveillance tracking etc.

The proposed course aims at introducing the foundations of Deep learning to various professionals who are working in the area of automation, machine learning, artificial intelligence, mathematics, statistics, and neurosciences (both theory and applications).

This is proposed course to introduce Neural networks and Deep learning approaches (mainly Convolutional Neural networks) and give few typical applications, where and how they are applied. The following topics will be explored in the proposed course.

We will cover a range of topics from basic neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning, and applications to problem domains like speech recognition and computer vision.

TextBooks/References:

1. Duda, R.O., Hart, P.E., and Stork, D.G. Pattern Classication. Wiley-Interscience. 2nd Edition. 2001.
2. Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition 4. Academic Press, 2008.
3. Russell, S. and Norvig, N. Articial Intelligence: A Modern Approach. Prentice Hall Series in Articial Intelligence. 2003.
4. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995.
5. Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning. Springer. 2001.
6. Koller, D. and Friedman, N. Probabilistic Graphical Models. MIT Press. 2009.

AV491 ADVANCED SENSOR AND INTERFACE ELECTRONICS (3-0-0) 3 Credits

Introduction and Background of state-of-art sensing and measurement techniques. Contactless potentiometer (resistance-capacitance scheme) – Methodology, Interface Circuits, Overview of Flight Instrumentation.

Analog Electronic Blocks, CMRR Analysis (Non-ideal opamps) of an Instrumentation Amplifier, Linearization circuits for single-element wheatstone bridges (application to strain gauge), Direct Digital Converter for Strain gauges, Signal conditioning for Remote-connected sensor elements.

Inductive sensors and electronic circuits, Eddy-current based sensors, Synchros and Resolvers, Magnetic shielding techniques.

State-of-art Magnetic Sensors – Principle, Characteristics and Applications – Induction Magnetometer, Flux gate Magnetometer, Hall Effect Sensor, Magnetoresistance Sensors, GMR Sensors – Multi-layer and Spin Valve, Wiegand Effect, SQUID.

Case Study-1: GMR Based Angular Position Sensor, Sensing Arrangement, Linearization Electronics – Methodology, Circuit Design and Analysis.

Case study-2: Brake Wear Monitoring, Reluctance-Hall Effect Angle Transducer–Sensing arrangement, Front-end Electronics. Overview of Basic Capacitive sensors.Various design considerations; guarding, stray fields, offset and stray capacitance, Ratio metric measurement – advantages and circuit implementations. RMS, Peak, Average Value Electronic Schemes for Capacitive Sensors, Synchronous Phase Detection – multiplier and switching type.

Case study-3: Liquid level detection – Concentric Cylindrical Plates, Plates on container walls – Dielectric and Conductive Liquids - Analysis. Case study-4: Capacitive Angle Transducers and Front-end electronics.

Piezoelectric sensors, Seismic transducers. Introduction to MEMS, Piezoelectric, Electrodynamic and MEMS Capacitive Accelerometers, Principles of Ultrasonic sensors - Equivalent circuit and transfer function of a piezoelectric transmitter, crystal oscillator. NDT using ultrasonic and eddy-current. Optical and Fibre Optic Sensors

MEMS Pressure sensors, Vaccum-pressure estimation and important flow measurement (volume and mass flow rate) schemes, Flapper-nozzle systems. Sensing Schemes for Attitude, Position measurement and navigation, Instrumentation Systems for Occupancy Detection – Ultrasound, Inductive and Capacitive schemes. Non-contact current and voltage measurement, Newhuman vital-sign sensing techniques.

TextBooks:

1. Ramón Pallás-Areny,John G. Webster, Sensors and Signal Conditioning, 2nd Edition, Wiley, 2003
2. Doebelin, E.O., Measurement systems: Application and Design, 5th ed., McGraw hill, 2003.

References:

1. J. G. Webster, The Measurement, Instrumentation and Sensors Handbook, Vol 1 and 2, CRC Press, 1999

2. L. K. Baxter, Capacitive Sensors – Design and Applications, IEEE Press Series on Electronic Technology, NJ (1997)
3. Jacob Fraden, Handbook of Modern Sensors – Physics, Designs and Applications, Springer, 4th Edition, 2010
4. John P. Bentley, Principle of Measurement Systems, Pearson Education; 3rd Edition, 2006
5. A. Barua, Fundamentals of Industrial Instrumentation, Wiley, 2013

Course Outcomes:

Course Outcomes	Statement
CO1	Understanding and analysis the advanced analog interfacing electronic schemes for sensors and their error and noise analysis.
CO2	Understanding the various digital front-ends for sensors present in practically-relevant scenerios.
CO3	Study of the principle of state of the art magnetic sensors, basic interfacing and applications.
CO4	Understanding the capacitive and inductive sensing modules and associated signal conditioning techniques.
CO5	Analyze electronic principles and allied technologies used in the industry.
CO6	Design and evaluate efficient sensor-electronic systems with the help of case studies.

AV492 CONTROL OF ELECTRIC DRIVES (3-0-0) 3 Credits

Introduction: Electro-mechanical energy conversion, classification of electric drives, requirements of electric drives. Selection of motors for different applications, estimation of torque requirements for sinusoidal and trapezoidal profiles, load locus analysis.

DC Motor Drives : Basic principles, different types of DC Drives, Dynamic models, speed-torque characteristics, different control schemes like torque control, closed loop speed and position control schemes. Digital implementation of control loops, velocity control, current control and sampling requirements and stability.

Induction Motor Drives: Modeling of Induction Motors, speed-torque characteristics, control of Induction Motors, closed-loop operation.

Control of special electric motors: Control of Brush-less DC Motor: different commutation schemes, advantages, Switched Reluctance Motor and Stepper Motor, Control of synchronous reluctance motor.

TextBooks/References:

1. Paul C Krause, Oleg Wasynczuk, Scott D Sudhoff, Analysis of Electric Machinery and Drive System, Wiley Inter-science, 2013
2. Leonhard W., Control of Electrical Drives, Springer-Verlag, 1985
3. Mohan, Undeland and Robbins, Power Electronics : Converters, Application and Design, John Wiley and Sons, 1989
4. Krishnan, R., Electric Motor drives: Modelling, Analysis and Control, Prentice Hall, March 2001

AV493 MACHINE LEARNING FOR SIGNAL PROCESSING (3-0-0) 3 Credits

Introduction: Representing text, Sounds and Images text, speech, image, and video. Signal processing for feature extraction: for Text (BoW), Speech (LPC, Mel-frequency Capstral coefficients, STFT and Wavelet features), Images (HoG, BoVW, FV), Videos (BoVW). Machine Learning basics - Introduction to pattern recognition, Bayesian decision theory, supervised learning from data, parametric and non parametric estimation of density functions, Bayes and nearest neighbor classifiers, introduction to statistical learning theory, empirical risk minimization, discriminant functions, learning linear discriminant functions, Perceptron, linear least squares regression, LMS algorithm, Supervised and Unsupervised learning, Classification and Regression (linear models), Evaluation metrics, Probability Models and Expectation-Maximization Algorithm, Gaussian Mixture Models, Neural Networks and Deep Learning, Multi-class classification and Multi-label classification, Different kinds of non-linearities, objective functions, and learning methods, ML for Audio Classification, Time Series Analysis, LSTMs, and CNNs, ML for Speech Recognition, Hidden Markov Models, Finite State Transducers and Dynamic Programming, ML for Music Information Retrieval, Latent Variable Models, Matrix Factorization and Signal Separation, ML for Image Processing, Transfer Learning, Attention models, Attribute-based learning, ML for Communication, Deep learning for wireless applications

Text books:

1. Pattern Classification (Pt.1) 2nd Edition, by Richard O. Duda (Author), Peter E. Hart (Author), David G. Stork (Author)
2. “Pattern Recognition and Machine Learning”, C.M. Bishop, 2nd Edition, Springer, 2011.
3. SergiosTheodoridis, "Machine Learning: A Bayesian and Optimization Perspective". Elsevier, 2015.

Refereces:

1. Deep Learning By Ian Goodfellow, YoshuaBengio, Aaron Courville Online book, 2017
2. Neural Networks and Deep Learning By Michael Nielsen Online book, 2016
3. Deep Learning with Python By J. Brownlee
4. Deep Learning Step by Step with Python: A Very Gentle Introduction to Deep Neural Networks for Practical Data Science By N. D. Lewis
5. “Pattern Recognition and Machine Learning”, C.M. Bishop, 2nd Edition, Springer, 2011.
6. “Machine Learning for Audio, Image and Video Analysis”, F. Camastra, Vinciarelli, Springer, 2007.
7. "Automatic Speech Recognition: A Deep Learning Approach", D. Yu and L. Deng, Springer, 2016.
8. Aurelio Uncini, "Introduction to Adaptive Algorithms and Machine Learning", 2018 .
9. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective". The MIT Press, 2012.
10. SergiosTheodoridis, "Machine Learning: A Bayesian and Optimization Perspective". Elsevier, 2015.
11. DaniloComminiello and José C. Príncipe (Eds.), "Adaptive Learning Methods for Nonlinear System Modeling". Elsevier, 2018.

AV494 IMAGE AND VIDEO PROCESSING (3-0-0) 3 Credits

Human visual system and image perception; monochrome and color vision models; image digitization, display, and storage; 2-D signals and systems; image transforms- 2D DFT, DCT, KLT, Haar transform, and discrete wavelet transform; image enhancement: histogram processing, spatial-filtering, frequency-domain filtering; image restoration: linear degradation model, inverse filtering, Wiener filtering; image compression: lossy and lossless compression, image compression standards; image analysis: edge and line detection, segmentation, feature extraction, classification; image texture analysis; morphological image processing: binary morphology- erosion, dilation, opening, and closing operations, applications; basic gray-scale morphology operations; color image processing: color models and color image processing. Fundamentals of digital video processing- Coverage includes Spatio-temporal sampling, motion analysis, parametric motion models, motion- compensated filtering, and video processing operations. Advanced topics related to recent trends in image processing and computer vision. Prerequisite: Linear algebra, Probability, and statistics, deep interest in programming

Text / References books:

1. Digital Image Processing by Rafael C. Gonzalez, Pearson
2. Image Processing: The Fundamentals, Second Edition, Maria M. P. Petrou, Costas Petrou.

AV495	MODELING OF LAUNCH VEHICLE AND SPACE CRAFT DYNAMICS	(3-0-0) 3 Credits

Coordinate systems, Attitude dynamics and control, Rotational kinematics, Direction cosine matrix, Euler angles, Euler's eigen axis rotation, Quaternions, Rigid body dynamics of launch vehicle, Angular momentum, Inertia matrix, Principal axes, Effect of aerodynamics, Generalized equations of motion, derivation of dynamic equations, structural dynamics and flexibility, propellant sloshing, actuator dynamics, gimballed engine dynamics, External forces and moments, Linear model for Aero-structure-control-slosh interaction studies. Space craft dynamics, Natural motions of rigid space craft, Translational motion in space, Translational motions in circular orbit, Rotational motion in space, rotational motion in circular orbit, Disturbances, Space craft sensors and attitude determination, Attitude control with thrusters and reaction wheels, Attitude stabilization with spin and generalized momentum wheels.

Text Books/References:

1. J.H.Blakelock, Automatic control of Aircraft and Missiles, Wiley India,1991
2. A.L.Greensite, Control Theory Vol. II- Analysis and Design of Space Vehicle Flight Control Systems, Spartan Books, 1970
3. N V Kadam, Practical design of flight control systems for launch vehicles and Missiles, Allied Publishers Pvt. Ltd., 2009
4. Brian L. Stevens, Frank L. Lewis, Aircraft Control and Simulation, Wiley, 2003
5. K. J. Ball, G. F. Osborne, Space vehicle dynamics, Clarendon P., 1967
6. A. L. Greensite, Analysis and Design of Space Vehicle Flight Control Systems – Short Period Dynamics, Vol 1, NASA
7. A. L. Greensite, Analysis and Design of Space Vehicle Flight Control Systems, - Trajectory Equations Vol 2, 1967, NASA

AV496	SATELLITE COMMUNICATION	(3-0-0) 3 Credits

Analog and digital communication schemes for satellite communication – AM and FM schemes, PCM, TDM, digital carrier systems, carrier recovery. Error control coding - linear block codes, cyclic codes, convolutional codes, coding gain, Shannon's capacity theorem, Turbo and LDPC codes. Modelling the space link - frequency allocation for satellite communication, satellite orbits and link availability, radio wave propagation for satellite communication – atmospheric losses, ionospheric effects, rain attenuation, antennae for satellite communication. Polarization effects in satellite communication – antenna polarization, ionospheric depolarization, rain depolarization, ice depolarization. Equivalent isotropic radiated power, transmission losses, link power budget, system noise, carrier to noise ratio, effects of rain, intermodulation noise, intersatellite links. Interference in satellite systems. Multiple access methods for satellite communication - FDMA, TDMA, CDMA. Introduction to satellite networks. Examples of services using satellites - direct broadcast television satellites, satellite mobile, GPS.

Text Books/References:

1. Dennis Roddy - Satellite Communications, 4th edition, McGraw Hill.
2. Bruce R. Elbert - Introduction to Satellite Communication, 3rd edition, Artech House
3. Timothy Pratt, Charles W. Bostian - Satellite Communications, John Wiley and Sons

AV497 COMPLEX NETWORKS (3-0-0) 3 Credits

Graph Theory Preliminaries. Introduction to Complex Networks. Centrality Metrics. Community Detection in Complex Networks. Random Networks. E-R random networks. Properties of Random Network. Real-world examples of random networks. Small-World Networks. Creation of Deterministic Small-World Networks. Anchor Points in a String Topology Small-world Network. Routing in Small-World Networks. Capacity of small-world Networks. Scale-Free Networks. Characteristics of Scale-Free Networks. Real-world examples of Scale-free networks. Preferential Attachment based Scale-Free Network Creation. Greedy Decision based Scale-Free Network Creation. Social Networks. Algorithms for social networks. Applications of social network analysis. Small-World Wireless Mesh Networks. Architectures and protocols for small-world wireless mesh networks, Small World Wireless Sensor Networks. Energy efficiency design in small-world wireless sensor networks. Signal processing over complex networks. Other relevant topics in Complex Networks.

TextBooks/References:

1. Ernesto Estrada, The Structure of Complex Networks, Oxford University Press (Reprint edition: August 2016.
2. Mark Newman, Networks: An Introduction, OUP Oxford; 1 edition, March 2010.
3. Piet van Mieghem, Graph Spectra for Complex Networks, Cambridge University Press, October 2012.
4. B. S. Manoj, Abhishek Chakraborty, and Rahul Singh, Complex Networks: A Networking and Signal Processing Perspective, Pearson, New York, February 2018.

AV498	INTRODUCTION TO COMPUTER VISION	(3-0-0) 3 Credits

Image Formation Models, Monocular imaging system, Orthographic & Perspective Projection , Camera model and Camera calibration, Image representations (continuous and discrete), Edge detection. Feature Extraction : Harris corner detector, SIFT, HoG descriptor; Multiresolution Analysis; Global motion estimation: Affine and Projective; Motion Estimation : Optical flow computation, Laplacain and Gaussian pyramids; KLT tracker, Other trackers; Depth estimation: Structure from motion; Binocular imaging systems, Stereo Vision, Fundamental matrix estimation, RANSAC, Image rectification and disparity estimation; Image Segmentation: Snakes and active contours; Viola Jones face detection, Face representation: Eigen faces and 2D PCA.

Prerequisite: image processing fundamentals, Linear algebra, Probability, and statistics, deep interest in programming

TextBooks/References:

1. Simon Prince, Computer Vision: Models, Learning, and Interface, Cambridge University Press.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010.
3. Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice-Hall, 2002.

AV499	APPLIED MARKOV DECISION PROCESSES AND REINFORCEMENT LEARNING	(3-0-0) 3 Credits

Review of basic probability and stochastic processes. Introduction to Markov chains. Markov models for discrete time dynamic systems, Reward, Policies, Policy evaluation, Markov decision processes, Optimality criteria, Bellman's optimality principle, Dynamic programming, Optimality equations, Policy search, Policy iteration, Value iteration. Generalized Policy Iteration, Approximate dynamic programming.

Exploration versus Exploitation in Reinforcement learning, Multiarmed and Contextual Bandits, Reinforcement learning setup and Model free learning, Monte Carlo learning, Q-learning & SARSA, Temporal difference learning, Function approximation, Policy gradient methods, Actor-critic methods, Stochastic approximation and its applications to reinforcement learning, Neural networks in reinforcement learning, Deep reinforcement learning.

Applications and case studies of Markov decision processes and Reinforcement Learning in Machine Learning, Control, Communication, Robotics, and Optimization.

Text Books/References:

1. Richard S. Suttonand Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2018.
2. Dimitri P.Bertsekas, Dynamic programming and optimal control. Vols. I and II, Athena scientific, 2005.
3. Sheldon M. Ross. Applied probability models with optimization applications. Courier Corporation, 2013.
4. Sheldon M. Ross. Introduction to stochastic dynamic programming. Academic press, 2014.

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand probability, stochastic processes (especially Markov chains) and their use in modelling of discrete time stochastic system.
CO2	Understand the theory of Markov decision processes and the problem of controlling discrete time.
CO3	Apply various methods (such as value iteration and policy iteration) for solving Markov decision processes. Dynamical systems and their formulation as Markov decision problems.
CO4	Understand the reinforcement learning framework and the fundamental problems of exploration-exploitation dilemma and credit assignment.
CO5	Understand, design, and implement reinforcement learning agents and apply them to real world problems.

AV500 MODELLING AND CONTROL OF ROBOTIC SYSTEMS (3-0-0) 3 Credits

Introduction: Components and mechanisms of robotic systems, Robot Manipulators, Wheeled Robots, Legged robots, Autonomous Robots, Joint actuators and Sensors.
Robot Kinematics: Rotation Kinematics, Rotation matrix, Euler angles, Axis-angle representation, Rodrigues formula, Different types of Coordinate transformations, Kinematics of rigid motion, Homogeneous transformation, Modified DH Convention, Typical examples Differential Kinematics and Statics: Joint configuration space and Task space of robots, Jacobian matrix and Differential motion, Kinematic singularities, Redundancy analysis, Closed loop Inverse Kinematics, Statics, Kineto-static duality, Velocity and force transformations, Spatial vector algebra, Unified representation for rigid motion, Rigid body transformation matrix. Dynamics: Joint space inertia matrix, Computation of kinetic and potential energies, Dynamical model of simple manipulator structures, Dynamics of Serial chain multibody systems, Euler-Lagrange and Newton-Euler formulations, Forward dynamics and inverse dynamics Motion control: The control problem, Joint space control, Decentralized control, Computed torque feedforward control, Centralized control, PD Control with gravity compensation, Inverse dynamics control, Task space control, Control of redundant robotic manipulators. Force Control: Manipulator interaction with environment, Compliance control, Impedance control, Force control, Constrained motion, Hybrid force/motion control

Text/Referencesbooks:

1) Course notes on " Modelling and Control of Robotic Systems" by Sam K Zachariah.
2) M.W.Spong, S.Hutchinson and M. Vidyasagar, Robot Modelling and Control, John Wiley & Sons Inc., 2006.
3) Abhinandan Jain, Robot and Multibody dynamics – Analysis and Algorithms, Springer, 2011
4) Edward Y.L. Gu , A Journey from Robot to Digital Human, Springer, 2013
5) B.Siciliano, L. Sciavicco, L. Villani, G.Oriolo, Robotics- Modelling, Planning and Control, Springer, 2009.
6) B. Siciliano, O. Khatib (Eds), Springer Handbook of Robotics, Springer, 2008.
7) S.V.Shah, S.K. Saha and J. K. Dutt, Dynamics of Tree-Type Robotic Systems, Springer, 2018

AV501	POWER ELECTRONICS	(3-0-0) 3 Credits

Introduction: Introduction to power electronics – basic elements – basic power electronic converters - survey of semiconductor devices – realisation of single-quadrant, two-quadrant and four-quadrant switches - requirements of power converters – applications of power electronics.
Dc-dc converters: Introduction – linear mode power conversion – switched mode power conversion – buck converter, boost converter, buck-boost converter, Cuk converter - Isolated converters: forward converter, fly back converter – Introduction to resonant converters
Dc-ac converters: Introduction - voltage source inverter - current source inverter - square wave and PWM inverters (single phase and three-phase) – PWM techniques.
Ac-dc converters: Controlled and uncontrolled rectifiers (single phase and three phase) – power factor, harmonics – active front end rectifiers.
Applications: AC / DC Drives, space applications, other industrial and utility applications - Practical converter design issues – control of power electronic converters - introduction to digital controllers for power electronic converters.

Text Books /References:

1. Ned Mohan, Tore M. Undeland, William P. Robbins: Power Electronics – Converters, Applications and Design; published by John Wiley & Sons Inc.
2. Daniel W. Hart: Power Electronics ; published by Tata McGraw Hill
3. Philip T Krein: Elements of Power Electronics; published by Oxford University Press
4. Robert W Erickson, DragoaMaksimovic: Fundamentals of Power Electronics; published by Springer
5. Joseph Vitahyathil, Power Electronics - Principles and Applications; Tata McGraw Hill
6. L. Umanad, Power Electronics - Essentials and Applications; Wiley India Pvt. Ltd
7. M H Rashid, Power Electronics - Circuits, Devices and Applications; PHI, New Delhi.
8. P.C. Sen, Modern Power Electroncis; published by Wheeler Publishers, New Delhi

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand basic concepts of switched mode power conversion, selection of switching devices and reactive elements.
CO2	Analyze the functioning of different types of power electronic converters and their control schemes
CO3	Selection and design of power electronic converters by assessing the requirements of application fields.
CO4	Analyze the system level performance of power electronic converters.
CO5	Identify the critical areas in applications and select suitable power converters to control electric drives and other industry grade apparatus.

AV502	SATELLITE AND OPTICAL COMMUNICATION	(3-0-0) 3 Credits

Optical fibers fundamentals – total internal reflection, single mode and multimode fibers, step index, graded index fibers, attenuation effects, cut-off wavelengths, linear and non-linear scattering losses, fiber bend losses, intra and intermodal dispersion, fiber dispersion, dispersion compensating fibers, polarization maintaining fibers, optical fiber connectors, fiber alignment and join losses, fiber splices, expanded beam connectors, fiber couplers. Optical sources and detectors - LEDs, LED structures, injection laser diodes, PIN photo detectors, avalanche photo diodes, photo detector noise. Optical modulation and modulators, Optical amplifiers. Design of an optical communication link, OTDR. Optical networks - SONET/SDH, WDM networks, non linear effects on network performance, solitons, optical CDMA.

Analog and digital communication schemes for satellite communication – AM and FM schemes, PCM, TDM, digital carrier systems, carrier recovery. Error control coding - linear block codes, cyclic codes, convolutional codes, coding gain, Shannon's capacity theorem, Turbo and LDPC codes. Modelling the space link - frequency allocation for satellite communication, satellite orbits and link availability, radio wave propagation for satellite communication – atmospheric losses, ionospheric effects, rain attenuation, antennae for satellite communication. Polarization effects in satellite communication – antenna polarization, ionospheric depolarization, rain depolarization, ice depolarization. Equivalent isotropic radiated power, transmission losses, link power budget, system noise, carrier to noise ratio, effects of rain, intermodulation noise,intersatellite links. Interference in satellite systems. Multiple access methods for satellite communication - FDMA, TDMA, CDMA. Introduction to satellite networks. Examples of services using satellites - direct broadcast television satellites, satellite mobile, GPS.

Textbooks / References:

1. Gerd Keiser - Optical fiber communication, McGraw Hill
2. John M. Senior - Optical fiber communication, Pearson
3. J. Gower - Optical communication systems, Prentice Hall
4. Dennis Roddy - Satellite Communications, 4th edition, McGraw Hill.
5. Bruce R. Elbert - Introduction to Satellite Communication, 3rd edition, Artech House
6. Timothy Pratt, Charles W. Bostian - Satellite Communications, John Wiley and Sons

Course Outcomes (COs):

Course Outcomes	Statements
CO1	Understand total internal reflection, Snell's law, Understanding construction and light guiding mechanisms in waveguides [optical fibers and planar waveguides], Understanding different types of Optical fibers, loss and dispersion mechanisms
CO2	Analyse different types of optical fiber components and optoelectronic devices [LASER/LED, modulators/switches, detectors] that are used in optical communication, Learning to design a optical communication link and test it
CO3	Understanding various error control codes – [linear block codes, cyclic codes, convolutional codes], coding gain, Shannon's capacity theorem, Turbo and LDPC codes
CO4	Analyze loss effects in satellite links, designing a satellite link, satellite networks and multiple access

AV503 NAVIGATION SYSTEM AND SENSORS (3-0-0) 3 Credits

Introduction to navigation, vehicle modeling, beacon-based navigation systems. Introduction to Inertial Sensors and Inertial Navigation. Initial Calibration and Alignment algorithms. Global Positioning System (GPS). GPS /INS data fusion algorithms. Simultaneous Localization and Mapping (SLAM), Practical applications of vehicle navigation systems in both structured and unstructured environments, sensor fusion.

Textbooks/References:

1. Slater J.M., Donnel C.F.O, Inertial Navigation Analysis and Design, McGraw Hill, New York, 1964.
2. Myron Kyton, Walfred Fried, Avionics Navigation Systems, 2nd edition, John Willy & Sons, 1997.
3. Albert D. Helfrick, Modern Aviation Electronics: 2nd Ed., PHI, 1994.

AV504	EMBEDDED SYSTEMS AND APPLICATIONS	(3-0-0) 3 Credits

Review of Embedded Hardware: Gates - Timing Diagram - Memory - microprocessors. Interrupts Microprocessor Architecture - Interrupt Basics - Shared Data Problem - Interrupt latency.

Software Development: Round-Robin, Round robin with Interrupts, function-Queue - Scheduling Architecture, Algorithms. Introduction to - Assembler - Compiler - Cross Compilers and Integrated Development Environment (IDE). Object-Oriented Interfacing, Recursion, Debugging strategies, Simulators.

Embedded Microcomputer Systems - Motorola MC68H11: Motorola MC68H11 Family Architecture, Interfacing methods.

Microchip PIC Microcontroller: Introduction, CPU Architecture - Registers - Instruction sets addressing modes - Loop timing - Timers - Interrupts, Interrupt timing, I/O Expansion, I2C Bus Operation Serial EEPROM, Analog to Digital converter, UART - Baud Rate - Data Handling - Initialization, Special Features – Serial Programming - Parallel Slave Port.

Real-Time Operating Systems, Task and Task States, Tasks and data, Semaphores and shared Data Operating system Services - Message queues - Timer function - Events - Memory Management, Interrupt Routines in an RTOS environment, Basic design using RTOS.

Networked embedded systems. Applications of networked embedded systems. Wireless sensor networks.

TextBooks/ References:

1. Wayne Wolf, Computers as Components - Principles of Embedded Computer System Design, Morgan Kaufmann Publisher, 2006.
2. David E. Simon, An Embedded Software Primer, Pearson Education, 2007.
3. K.V.K.K. Prasad, Embedded Real-Time Systems: Concepts, Design & Programming, Dreamtech Press, 2005.
4. Tim Wilmshurst, An Introduction to the Design of Small Scale Embedded Systems, Palgrave Publisher, 2004.
5. Sriram V. Iyer, Pankaj Gupta, Embedded Real-Time Systems Programming, Tata Mc-Graw Hill, 2004.
6. Tammy Noergaard, Embedded Systems Architecture, Elsevier, 2006.