Department of Physics
Banasthali Vidyapith, Banasthali

Minutes of the meeting of the Board of Studies in Physics held on 24th April 2016 at 01:00 PM in the Conference Room-I, Department of Physics, Banasthali Vidyapith

PRESENT

1. Prof. N. K. Jaiman : External Member
2. Dr. Ajay Singh Verma : Internal Member
3. Dr. Devendra Pratap Singh : Internal Member
4. Dr. Jhuma Gope : Internal Member
5. Dr. Parvez Ahmad Alvi : Internal Member
6. Dr. Saral Kumar Gupta : Internal Member
7. Dr. Vineet Tiwari : Internal Member
8. Dr. Vishant Gahlaut : Internal Member

Prof. V. K. Sharma, Department of Physics, University of Rajasthan, Jaipur (External Member), Dr. Dr. Pooja Bhambhani (Internal Member), Dr. Shweta Parashar (Internal Member) and Prof. D. R. Phalaswal (Convener) could not attend the meeting.

1. The board confirmed the minutes of its last meeting of the Board of Studies held on 12th March 2012.
2. The board has revised the syllabus of M. Tech. Nanotechnology course. The revised syllabus is enclosed as **Annexure–I.**
3. The board has recommended the course structure and the syllabi of new course: M. Tech. (Renewable Energy) programme and is enclosed as **Annexure–II.**
4. The format of handout was checked by the board and the board has given no new suggestion on format of the handout.
5. The board has checked the text books as well as reference books mentioned in the syllabi of UG and PG courses and found that all the books are relevant, and recommended no new books.
6. The board has discussed about continuous assessment policy and found that current policy is satisfied.
7. The board has recommended some new examiners for theory and practical examinations to be added in already existing panels.
8. The board has recommended and verified the course of study, curricula and schemes of UG and PG examinations. The board has suggested few modifications in B.Sc. and M.Sc. course as follows:

I. The board has recommended to change the title of B.Sc. V semester course: from Quantum, Atomic and Molecular Physics (old title) to Quantum mechanics and Spectroscopy (new title). Some other modifications have also been suggested by the board, and are enclosed as **annexure-III.**

II. The Board has suggested some modifications in M.Sc. III semester courses: Solid State Physics and Condensed matter Physics-I. The revised syllabi are enclosed as **Annexure –IV.**

III. The Board has suggested some modifications in M.Sc. IV semester courses: Solid State Electronic Devices, Microwave electronics and Condensed matter Physics-II. The revised syllabi are enclosed as **Annexure –V.**

Note : All above changes will be applicable from the session – 2016-17.

9. The board has reviewed the reports received from the examiners of different examinations and found that reports were satisfactory and the performance of the students in most of the papers is upto the mark.
10. The board has evaluated the question papers of the periodical and semester examinations and found that the quality of the question papers is maintained at UG and PG level.
11. The list of experiments of UG and PG course was examined by the board. The board has modified the experiments according to the theory course and also added some new experiments.

The meeting ended with a vote of thanks to the chair.

MN1.3 Surfaces and Interfaces and thin films

M. Tech. (Nanotechnology)

Existing	Modified	Justification
SECTION A: Vacuum techniques: Introduction, Important areas of application basic definations of vacuum technology, vacuum pumps: rotary Vane pumps, sorption pumps, Diffusion pumps, Turbo molecular pumps, Ion Pumps, cryogenic pumps, Vacuum gauges: McLeod gauge, Diaphragm gauge, Pirani guage.	**SECTION A:** Vacuum technologies: Introduction, Important areas of application basic definitions of vacuum technology, vacuum pumps: rotary Vane pumps, sorption pumps, Diffusion pumps, Turbo molecular pumps, Ion Pumps, cryogenic pumps, Vacuum gauges: Thermocouple gauge, McLeod gauge, Diaphragm gauge, Pirani guage, Pennying gauge	Knowledge of these gauges is very much needed as these gauges are generally used in vacuum systems used in research laboratories.
SECTION B: **Growth and Analysis:** Stanski-Krastnow growth method, Analysis of surfaces: structure analysis using AFM, STM, LEED, chemical analysis using XPS, AES Introduction to crystal lattice: Relaxation and reconstruction at surfaces, adsorption, physisorption and chemisorption, stepped and kinked surfaces.	**SECTION B:** **Growth and Analysis:** Thin Film Deposition Mechanism: Homogeneous (Step propagation, Island growth) and heterogeneous (Frank-Vander Merwe Model, Volmer-Weber Model, Stanski-Krastanov model) film growth, Analysis of surfaces: structure analysis using AFM (Principle, working and operational modes), STM: (Principle, working and operation modes), LEED, chemical analysis using XPS, AES, Capacitance-Voltage (C-V) measurement technique for the determination of interface quality. Introduction to crystal lattice: Surface Energy, Wulff Construction and equilibrium shape for nanoparticles, Relaxation and reconstruction at surfaces, adsorption, physisorption and	Knowledge of homogeneous and other heterogeneous film growth method beside Stanski-Krastanov model is necessary for understanding of different growth mechanisms. At least one technique for interfacial property should be taught. Important for the understanding of the role of surface energy.

	chemisorption, stepped and kinked surfaces.	
SECTION C: **Liquid surfaces and morphology**: Roughness and its statistical description, height probability distribution, Gaussian probability distribution, correlation functions, transformation to reciprocal surface, Fractals, fractal dimension, self-similarity, self-affinity, self-affine surfaces, ~~Capillary waves on liquid surfaces.~~ Principles of characterization techniques: Grazing incidence x-ray scattering techniques and surface sensitivity, x-ray and neutron reflectivity.	**SECTION C:** **Liquid surfaces and morphology**: Roughness and its statistical description, height probability distribution, Gaussian probability distribution, correlation functions, transformation to reciprocal surface, Fractals, fractal dimension, self-similarity, self-affinity, self-affine surfaces, Principles of characterization techniques: Grazing incidence x-ray scattering techniques and surface sensitivity, x-ray and neutron reflectivity.	Not necessary at this point

Books:

1. Introduction to surface science, by M. Prutton, Cambridge University Press
2. X-ray and neutron reflectivity, Principles and applications: Jean Daillant and Alan Gibaud, springer track
3. Vacuum Physics and Techniques by T.A. Delcher, Chapman & Hall.

MN 1.5 Nano-photonics and Optoelectronics

M. Tech. Nanotechnology I Sem.

Existing	Modified	Justification
Section A: III-V semiconductor Quantum Wells and Quantum Dots, Spectroscopic studies of QD ensembles: photoluminescence, measurements in Magnetic field, absorption measurements, ultra-fast spectroscopy. Single QD studies through micro-PL: Spin states. Manipulation of nuclear spin states. Optical cavites, Photonic gap materials. 1D microcavities, 2D/3D photonic structures. Optical manipulation of qubits. Quantum cryptography and optical approaches to quantum information processing.	**Section A:** III-V semiconductor Quantum Wells and Quantum Dots, Nonlinear Optical Properties, Quantum Confined Stark effect, Dielectric Confinement Effect, Superlattices, Core-shell Quantum dots and quantum dot-quantum wells, Quantum confined structures as lasing media, Photonic cruystals. 1D, 2D/3D photonic structures. Features of Photonic crystals, Microcavity effect, Methods of Fabrication (Self Assembly, Two Photon Lithography, E-beam Lithography, Holographic methods). Photonic crystal optical circuitry, Nonlinear Photonic Crystals, Photonic Crystal Fiber, Photonic Crystal Sensors.	For the systematic study of the subject, highlighted topics should be modified. Not necessary at this point, as these topics are related to Quantum Computation and Information Processing and thus will study in M.Tech II semester syllabus of "Quantum Computation and Information Processing".
Section B: Two level system, rate equations, Population inversion, Lasers. LED's. Heterojunction lasers, Guided Wave Optics, basic geometry, operating characteristics, losses, gain, gain band, modification of characteristic by lowered dimensionality, QW and QD Laser performance. Surface emitters, Microcavity lasers, Materials issues. Alternative cavity designs; micro-disk lasers, photonic band gap cavities. Unipolar devices: QCL devices for mid/near infrared. Principles	**Section B:** Introduction to Lasers, Guided waves, Gain in two level lasing medium, Lasing condition and gain in semiconductor, Selective amplification and coherence, Threshold condition for lasing, Lineshape function and line-broadening mechanisms, Lasing threshold condition in two level system, LED's: Choice of materials, Light output from LED, Semiconductor lasers: Basic principles, Heterojunction lasers: Energy band diagram and power output, Quantum Well and Quantum Dot	For the systematic study of the subject, these mentioned topics should be modified. These topics are not specifically mentioned Not necessary at this point.

of operation, Basic operating characteristics. Use of photonic structures to lower losses. Single Photon sources. Attenuated LED's, Single dot devices, true single photon sources, I and II order correlation functions, Hanbury Brown- Twiss experiment.	Lasers, Surface emitting lasers, Unipolar devices: Quantum Cascade Lasers: Structures and Principles of operation, Microcavity and Photonic Crystal lasers,	
Section C: Photodiodes , Avalanche Photo Diodes (APD), photon counting, materials requirements for APD's, limitations, after pulsing, quantum efficiency . Quantum dots as absorbers, standard current generation. QWIPs Quantum well infrared photodetectors (QWIPs). Operation principles, design and materials choices. Fabrication of planar arrays, spectral response, two colour detection. Quantum dot infrared photodetectors (QDIPs). Extending QWIPs into shorter and longer wavelengths.	**Section C:** Photodiodes, Avalanche Photo Diodes (APD), structure, materials, characteristics and device performance. Infrared quantum detectors, QWIPs Quantum well infrared photodetectors (QWIPs). Operation principles, design and materials choices. Quantum dot infrared photodetectors (QDIPs). Extending QWIPs into shorter and longer wavelengths.	For the systematic study of the subject, these mentioned topics should be modified Not necessary at this point.

Books:

1. Progress in Nano-Electro-Optics III Industrial Applications and Dynamics of the Nano-Optical System : Motoichi Ohtsu (Ed.) ISBN 3-540-21050-4 Springer Berlin Heidelberg New York 2005
2. Surface Plasmon Nanophotonics Mark L. Brongersma Pieter G. Kik (Ed) ISBN: 978-1-4020-4349-9 (HB) Springer 2007
3. Nanophotonic Materials Photonic Crystals, Plasmonics, and Metamaterials Edited by
4. R. B. Wehrspohn, H.-S. Kitzerow, and K. Busch Wiley VCH Verlag GmbH & Co KGaA 2008
5. PLASMONICS: FUNDAMENTALS AND APPLICATIONS by STEFAN A. MAIER ISBN 978-0387-33150-8 Springer 2007
6. Optical Metamaterials Fundamentals and Applications by Wenshan Cai and Vladimir Shalaev ISBN: 978-1-4419-1150-6 Springer
7. Semiconductor Optoelectronic devices by Pallab Bhattacharya, published by Pearson Education ISBN-978-81-203-2047-5
8. Physics of Photonic Devices by Shun Lien Chuang, John Wiley & Sons

MN 2.1 Nano-electronics

M. Tech. (Nanotechnology) II sem.

Existing	Modification	Justification
Section A Quantum tunneling, ballistic electron transport, 1D transport and Büttiker-Landauer formula, quantum point contact/quantized conductance, electron collimation effect, ~~solid-state electron optics negative-bend resistance and anomalous Hall effect,~~ breakdown of Ohm's law, quantum Hall effect and 1D edge states, quantum interference and Aharanov–Bohm effect~~, effect of high surface/bulk ratio on thermal dynamics,~~ noise in nanostructures.	**Section A** MOS structure, subthreshold characteristics, Short channel effects, punch through, velocity saturation, hot electron effects, CMOS scaling, device variability, interconnects; Bulk CMOS improvements: strained Si, high-K dielectrics metal gates, SOI MOSFETs, Double gate MOSFETs, FinFET, Memory devices: Phase change RAM, ferroelectric RAM, magnetic RAM.	B section is shifted to Section A, because Microelectronics devices part should come prior to the Nanoelectronics devices. And some part deleted like Principles of VLSI chip design, digital logic and memory devices. Because these topics Students have already studied in undergraduate course. And some topics added.
Section B ~~Principles of VLSI chip design, digital logic and memory devices.~~ CMOS scaling, challenges and limits: short channel effects, static power, device variability, interconnect; ~~ITRS;~~ Bulk CMOS improvements: strained Si, high-K dielectrics, metal gates, SOI; Novel device architectures: fully depleted ultra-thin body SOI, multiple -gate devices: planar double-gate, FinFET, tri-gate FET, Memory devices. Phase change RAM, ferroelectric RAM, magnetic RAM, ~~molecular memory.~~	**Section B** Important quantities in mesoscopic transport, ballistic electron transport, Magneto-transport properties of quantum films: Landau quantization, two-dimensional electron gases in perpendicular magnetic fields, The quantum Hall effect, conductance quantization in quantum pint contacts, the Landauer–Büttiker formalism, Edge states and channels, Quantum point contact circuits, Electronic Phase Coherence: quantum interference and Aharanov–Bohm effect, weak localization, noise in nanostructures.	Added deleted and sequence changed
Section C Limits of conventional microelectronics, Resonant tunneling devices, hot-electron	**Section C** Limits of conventional microelectronics, Quantum tunneling, Resonant tunneling devices, hot-	Added deleted and sequence changed.

transistors, Coulomb - blockade effect and single-electron transistor/memory, ~~quantized electron current carried by surface acoustic wave,~~ quantized conductance in ~~multi-wall~~ nanotubes, ~~branched electron flow paths and quantum switch~~, different types of ballistic rectifiers, nonlinear electronic nano-material, planar nano-diode and transistor, Y-switches, molecular electronics and nanotube transistors, organic semiconductor devices.	electron transistors, Coulomb-blockade effect and single-electron transistor, quantized conductance in CNTs, nanotubes, ballistic rectifiers, , planar nano diode and nano MOSFET, Y-switches, molecular electronics: Introduction, Electrodes and Contacts, Functions and Devices-First Test Systems), carbon nanotube transistors, Organic Semiconductors devices: Organic Light Emitting Diodes and Organic Displays.	

TEXT BOOKS:

1. Chenming Calvin Hu, "Modern Semiconductor Devices for Integrated Circuits", First edition, Pearson Education, Inc., 2010.

2. Yuan Taur, Tak H. Ning, "Fundamentals of Modern VLSI Devices", second edition, Cambridge university press, 2013.

3. Thomas Heinzel, "Mesoscopic Electronics in Solid State Nanostructures", second edition, WILEY-VCH, 2007.

4. Rainer Waser (Ed.), "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices", second edition, WILEY-VCH, 2003.

5. Ballistic Transistors M. Lundstrom and J. Guo, "Nanoscale Transistors: Physics, Modeling, and Simulation", Springer 2006.

6. George W. Hanson, " Fundamental of Nanoelectronics", First edition, Pearson Education, 2009.

REFERENCE BOOKS:

1. Tero T. Heikkilä, "The Physics of Nanoelectronics", OXFORD university press, first edition, 2013.

2. Byung-Gook Park, Sung Woo Hwang, Young June Park, "Nanoelectronic Devices", Pan Stanford publishing, Pte. Ltd. 2012.

3. Vladimir V. Mitin, Viatcheslav A. Kochelap Michael A. Stroscio, "Introduction to Nanoelectronics", Cambridge university press, 2012.

4. C. Y. Chang (Editor), Simon M. Sze (Editor), “ULSI Devices”, JOHN WILEY & SONS, INC, 2000.

5. S. Datta, “Electronic Transport in Mesocopic Systems. Cambridge University Press, 1995.

MN 2.2 Mathematical modeling and simulation

M. Tech . II sem. (Nanotechnology)

Existing	Modification	Justification
Section A **Fundamental principles of numerical methods:** Scientific Modeling, Numerical Algorithms, Programs and Software, Approximations in Mathematical model building, Numerical integration, Differentiation, Variation finite element methods, Raleigh's method, Ritz method. Mathematical modeling: physical simulation, process control, transport phenomena, concept of physical domain and computational domain, Finite element method and Finite difference method.	**Section A** **Modeling**: Scientific Modeling, Mathematical modeling, Numerical Algorithms, Fundamental principles of numerical methods (Programs and Software, Approximations in Mathematical model building, Numerical integration, Numerical differentiation, Finite element method and Finite difference method, Raleigh's method, Ritz method), physical simulation, process control, transport phenomena, concept of physical domain and computational domain,	A good syllabus should consist of channelized flow from one topic to another. This attribute was missing in section A; so imbibe in modified section A.
Section B **Ab-Initio methods:** Linear Combination of atomic orbtals method, Density function theory, Hartree and Hartree Fock methods, mean field approximation, statistical methods for many body system, spin-polarized relativistic Korringa-Kohn-Rostoker Green's function, Augmented Plane Wave, Full Potential-APW, Projector Augmented Plane wave, linear muffin tin orbitals and **k.p** methods.	**NO change**	

Section C **Simulation:** Basic concepts of simulation, data manipulation, data exchange of the structure, properties and processing of materials, Three dimensional model for capillary nanobridges, Molecular dynamics simulation. **Monte Carlo methods:** Basics of the Monte Carlo method, Algorithms for Monte Carlo simulation, Applications to systems of classical particles, variation Monte Carlo method, diffusion Monte Carlo method, Quantum Monte Carlo method.	**Section C** **Simulation:** Basic concepts of simulation, data manipulation, data exchange of the structure, properties and processing of materials, Three dimensional model for capillary nanobridges, Molecular dynamics simulation. **Monte Carlo methods:** Basics of the Monte Carlo method, Algorithms for Monte Carlo simulation, Applications to systems of classical particles.	In the given time frame, it's not possible to discuss the variants of Monte Carlo method; hence deducted from section C.

Text/Reference books:

1. Chapra. S.C.and Canale R.P.,Numerical methods for Engineers, Tata McGraw Hill, New Delhi, 2002.
2. Frenkel D. and Smith, B., Understanding molecular simulation from algorithm to applications, Kluwar Academic Press, 1999.
3. Ohno, K, Esfarjani. K. and Y. Kawazoe, Introduction to Computational Materials Science from ab-initio to Monte Carlo Methods, Springer-Verlag, 1999.

MN 2.3 Quantum Computation and Information Processing

M.Tech (Nanotechnology) II Sem.

Existing	Modified	Justification
Section A: Basics of Nanocomputing: Elements of Boolean Algebra and Binary System, Classical Logic Gates and Logic gate symbols (AND gate, OR gate, NOT gate, NAND gate, NOR gate, EXOR gate, EXNOR gate), Circuit Models. Linear Algebra and Dirac Notation : Hilbert Space, Operators, The Spectral theorem, Functions of Operators, Tensor Products, The Schmidt Decomposition Theorem.	**Section A:** Basics of Nanocomputing: Elements of Boolean Algebra and Binary System, Classical Logic Gates and Logic gate symbols (AND gate, OR gate, NOT gate, NAND gate, NOR gate, EXOR gate, EXNOR gate), Circuit Models. Linear Algebra and Dirac Notation : Hilbert Space, Operators, The Spectral theorem, Functions of Operators, Tensor Products, The Schmidt Decomposition Theorem	No modifications required
Section B: **Qubits and hypothesis of Quantum mechanics:** The state of a quantum system, Time evolution postulate, Superposition and composite System, Measurement postulate, Mixed states and general quantum operation **Quantum model of computation:** Quantum gates (one and two qubits gate), Universal set of quantum gates, Measurements with quantum circuits. Superdense coding, Quantum Teleportation and it application, Quantum Entanglement.	**Section B:** **Qubits and hypothesis of Quantum mechanics:** The state of a quantum system, Time evolution postulate, Superposition and composite System, Measurement postulate, Mixed states and general quantum operation **Quantum model of computation:** Quantum gates (one qubit gates and Controlled-U Gates), Universal set of quantum gates, Measurements with quantum circuits. Superdense coding, Quantum Teleportation and it application, Quantum Entanglement.	For the systematic study of the subject, mentioned topic should be modified.

Section C: **Introduction to Quantum algorithms:** Phase kick-back, The Deutsch Algorithm, The Deutsch-Jozsa Algorithm, Quantum phase estimation and quantum Fourier Transformation, Eigenvalue Estimation and finding orders, Shor's algorithm, Algorithms based on amplitude amplification. Grover's quantum Search algorithm, Search without knowing the success probability. Quantum Error Correction, Single-Qubit Measurement, Statistical Quantum computation, Adiabatic Quantum Computation, **Physical realizations of logic quantum gates in Quantum System:** Ion Trap Quantum Computer, Solid State Spin Quantum Computer, Superconductor Quantum Computer, Topological Quantum Computer, Liquid State Quantum Computer.	**Section C:** **Introduction to Quantum algorithms:** The Deutsch Algorithm, The Deutsch-Jozsa Algorithm, Quantum phase estimation and quantum Fourier Transformation, Eigenvalue Estimation and finding orders, Shor's algorithm, Grover's quantum Search algorithm, Quantum Cryptography, Quantum Error Correction, Single-Qubit Measurement, Adiabatic Quantum Computation, **Physical realizations of logic quantum gates in Quantum System:** Guiding Principles, Conditions for quantum computation, Harmonic oscillator quantum computer, Ion Trap Quantum Computer.	Not necessary at this point. For the systematic study of the subject, mentioned topic should be modified.

Text/Reference books:

1. An introduction to Quantum Computing by Phillip Kaye, Raymond Laflamme and Michele Mosca Oxford University Press.
2. Introduction to Quantum Computers by Gennady Berman, Gary Doolen, Ronnie Mainieri and Vladimir Tsifrinovich, Word Scientific.
3. Quantum computation and quantum information, by Michael A. Nielsen, Isaac L. Chuang

MN 2.4 Advanced characterization techniques

M. Tech. (Nanotechnology) II sem.

Existing	Modified	Justification
SECTION A: Diffraction techniques: Introduction to x-ray sources: sealed tube x-ray source, rotating anode x-ray source, synchrotron source, single crystal diffraction, powder diffraction, Low Energy electron diffraction (LEED), neutron diffraction: interaction of neutron with matter, scattering cross section, scattering length density, light scattering by colloidal dispersion, dynamic light scattering (DLS), static light scattering, hydrodynamic radius, zeta potential.	No Change	
SECTION B: Microscopes: Optical microscopy, fluorescence and confocal microscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM), ~~Photolithography, other optical lithography (EUV, x-ray,~~ LIL), p-beam lithography,~~ e-beam lithography, soft lithography, nano imprint lithography,~~ DTA, TGA, DSC techniques.	Microscopes: Optical microscopy, fluorescence and confocal microscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM). Lithography: Laser Interference Lithography (LIL), p-beam lithography. Thermal Analysis: DTA, TGA, DSC techniques.	Already covered in Semester I
SECTION C: Spectroscopy Techniques: Ultraviolet (UV) and x-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS), Rutherford back scattering, FTIR, UV-VIS, cathode luminescence and photo luminescence.	No Change	

Books :

1. Nanocomposite science and technology – P.M. Ajayan, L.S. Schadler, P.V. Braun, Wiley, New York.
2. Active Metals: Preparation, characterization, applications – A. Furstner, Ed., VCH, New York 1996.
3. Characterization of nanophase materials – Z.L Wang (ed), Wiley-VCH, New York 2000.
4. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
5. Nanostructured Silicon – based powders and composites – Andre P Legrand, Christiane Senemaud, Taylor and Francis, London New York 2003.
6. Polymer – clay Nanocomposite – T.J. Pinnayain, G.W. Beall, Wiley, New York 2001.
7. Block Co-polymers in Nanoscience – Massimo Lazzari, Guojun Liu, Sebastien Lecommandoux, Wiley, New York 2007
8. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.
9. Processing & properties of structural naonmaterials - Leon L. Shaw (editor)
10. Elements of X-ray Diffraction by Cullity, B. D.,, 4th Edition, Addison Wiley, 1978.
11. The Structure and Properties of Materials by Rose, R.M., Shepard L.A., and. Wulff, J., Wiley Eastern Ltd.
12. Electron Beam Analysis of Materials by Loretto, M. H., Chapman and Hall, 1984.

MN 1.1 Introduction to material science

M. Tech. (Nanotechnology)

Existing	Modification	Justification
Section A Need of material science and Engineering: Atomic bonding in solids, unit cells, primitive cell, crystal systems, Miller indices, crystallographic directions & planes, packing fraction, linear density, planer and theoretical densities of crystal structure, close-packed crystal structures, single crystal, polycrystals, amorphous structure, Introduction to XRD for the determination of crystal structure; Crystal imperfections: point defects, linear defects, surface defects, bulk and volume defects; ~~Polymers: Introduction, classification, polymer structure, copolymers, tacticity, geometric isomerism, molecular weight, molecular weight distribution, molecular weight averages, polydispersity index; Ceramics: Introduction to ceramic structure and applications of ceramics.~~	**Section A** Need of material science and Engineering: Atomic bonding in solids, unit cells, primitive cell, crystal systems, Miller indices, crystallographic directions & planes, packing fraction, linear density, planer and theoretical densities of crystal structure, close-packed crystal structures, single crystal, polycrystals, amorphous structure, Introduction to XRD for the determination of crystal structure; Crystal imperfections: point defects, linear defects, surface defects, bulk and volume defects; Plastic deformation, plastic deformation by slip, shear strength, motion of dislocation: effect of stress, temperature, grain size, solute atoms, precipitate particles, multiplication of dislocations, basic concepts of creep and fracture.	Part of C section is shifted in Section A, as per continuation of defects and dislocation with deformations. And polymer is shifted in section C.
Section B Introduction to Phase diagrams: Phase rule, Unary phase diagram, binary phase diagram (Al2O3, PbSn, Ag-Pt), Hume-Routhery rules for solid solutions, the lever rule. The tie line rule, Diffusion: Diffusion mechanism, Fick's law of diffusion, steady state and non-steady state,	**Section B** Introduction to Phase diagrams: Phase rule, Unary phase diagram, binary phase diagram (Al2O3, PbSn, Ag-Pt), Hume-Routhery rules for solid solutions, the lever rule. The tie line rule, the iron–carbon system Development of Microstructure in	**Introduction of Iron carbon system to understand phase diagram and different phase reactions.**

applications based on Fick's second law, kirendall effect; Phase Transformations: Nucleation, homogeneous, heterogeneous growth, Transformation kinetics, Time-temperature-transformation (TTT) curves, applications of nucleations & growth, glass transition.	Iron–Carbon Alloys. Diffusion: Diffusion mechanism, Fick's law of diffusion, steady state and non-steady state, applications based on Fick's second law, kirendall effect; Phase Transformations: Nucleation, homogeneous, heterogeneous growth, Transformation kinetics, Time-temperature-transformation (TTT) curves, applications of nucleations & growth, glass transition.	
Section C Mechanical behavior: Elastic, anelastic, viscoelastic behavior of materials, ~~modulus as a parameter in design. Plastic deformation, plastic deformation by slip, shear strength, motion of dislocation: effect of stress, temperature, grain size, solute atoms, precipitate particles, multiplication of dislocations, basic concepts of creep and fracture.~~ ~~Biomaterials: Protein Enzymes DNA, RNA.~~ Liquid Crystals and Quasi Crystals. Disposal of waste materials.	**Section C** Mechanical behavior: Elastic, anelastic, viscoelastic behavior of materials, Polymers: Introduction, classification, polymer structure, copolymers, tacticity, geometric isomerism, molecular weight, molecular weight distribution, molecular weight averages, polydispersity index; Ceramics: Introduction to ceramic structure and applications of ceramics. Liquid Crystals and Quasi Crystals. Disposal of waste materials. Composites: particle-reinforced composites, fiber-reinforced composites, structural composites	Introduction of Polymer is introduced with mechanical behavior of materials. Also composites are very important in material science.

Books:

1 Callister W. Jr. "material science and Engineering : An Introduction." John Willey and sons, 2007.

2. M. F. Ashby and D.R. H. Jones, "Engineering materials1 and 2", BH publication, 2002.

MN1.2 Fundamental of Nano-science and Nano-technology

M. Tech. (Nanotechnology) I sem

Existing	Modified	Justification
SECTION A: Nanostructures: Definition of nanoscience and nanotechnology, classification of the nano materials, zero dimensional nanostructures, one dimensional nanostructures-nanowires, nanorods and nanotubes, two dimensional nanostructures-graphene, Thinfilms, ~~three dimensional nanostructures.~~ Quantum Confinement: ~~Quantum confinement of electrons in semiconductor nanostructures,~~ Quantum dots(QDs), Quantum wires (QWRs), Quantum wells (QWs). Density of states in QDs, QWRs, QWs.	Nanostructures: Definition of nanoscience and nanotechnology, classification of the nano materials, zero dimensional nanostructures, one dimensional nanostructures-nanowires, nanorods and nanotubes, two dimensional nanostructures-graphene, Thinfilms, Quantum Confinement, Quantum dots(QDs), Quantum wires (QWRs), Quantum wells (QWs). Density of states in QDs, QWRs, QWs.	Three dimension nanostructure is not needed at this point. Quantum confinement is self explanatory.
SECTION B: Synthesis of Nanomaterials: Synthesis of nano-structured materials, sol-gel processing, microwave synthesis, self-assembly, Langmuir-Blodgett (LB) method, electrochemical deposition, chemical vapor deposition, Sputter deposition, pulsed laser deposition, magnetron sputtering, molecular beam epitaxy, lithography. ~~Properties of Nanomaterials. Shape and size dependant properties electrical, linear and nonlinear optical properties, magnetic, thermal and mechanical properties of~~	Synthesis of Nanomaterials: Synthesis of nano-structured materials, sol-gel processing, microwave synthesis, self-assembly, Langmuir-Blodgett (LB) method, electrochemical deposition, chemical vapor deposition, Sputter deposition, pulsed laser deposition, magnetron sputtering, molecular beam epitaxy, lithography.	Rearrange the section B and C as syllabus is extremely vast, it should be well arranged.

~~nanomaterials, melting point and lattice constants, surface plasma resonance.~~		
SECTION C: **Applications:** Nano-Heterostructures and quantum dot (Photodetectors and lasers). Nanotechnology in health and life sciences, ~~nanomaterials in tissue engineering, protein detection, nanostructured materials in biomedical implants, nanoporous membranes, biomedical applications of nanoparticles.~~	Properties of Nanomaterials. Shape and size dependant properties- electrical, linear and nonlinear optical properties, magnetic, thermal and mechanical properties of nanomaterials, melting point and lattice constants, surface plasma resonance. **Applications:** Nano-Heterostructures and quantum dot (Photodetectors and lasers).	Rearrange section B and C as syllabus is extremely vast, it should be well arranged.

Text/Reference books:

1. S.K.Kulkarni, Nano technology; principle and practices by, (Capital Publishing Company), 2007.
2. Guozhong Cao, Nanostructures and Nanomaterials–Synthesis, Properties and Applications, Imperial College Press, London, 2004.
3. Michael Kohler and Wolfgang Fritzsche, Nanotechnology-an introduction to Nanostructuring techniques, Wiley-VCH, 2004.
4. Emil Rodune, Nanoscopic materials - size dependant phenomena, Royal society of Chemistry publishing, 2006.

MN 1.4 Advanced synthesis processes and devices

M. Tech. (Nanotechnology) Ist Sem.

Existing	Modification	Justification
Section A Crystal Synthesis: Epitaxy and Epitaxial growth techniques. Thin film growth in Ultra High Vacuum environments, Molecular Beam Epitaxy; basic physical processes. Variants: Gas source MBE, Phase locked Epitaxy, Atomic Layer Epitaxy. Lattice mismatched heteroepitaxy: Sputtering, Chemical Vapour Deposition (CVD): MOCVD, LPCVD, PECVD.	**Section A** Approaches for nanomaterial fabrication: Top Down and Bottom up, Physical vapour deposition (PVD): Plasma Arc Discharge and Sputtering (DC, RF and RF Magnetron sputtering), Chemical vapour deposition (CVD): LPCVD, PECVD and MOCVD, Crystal Synthesis: Epitaxy and Epitaxial Growth techniques (Homoepitaxial and Heteroepitaxial growth mechanism), Molecular Beam Epitaxy (MBE), Variants: Gas source MBE, Phase locked Epitaxy, Atomic Layer Epitaxy. Lattice mismatched heteroepitaxy	- Prerequiste classifications should be discussed in prior than precise techniques Such as Approaches for nanomaterial fabrication: Top Down and Bottom up, Physical vapour deposition (PVD) Chemical vapour deposition (CVD) Epitaxy and Epitaxial Growth techniques Conventional and unconventional lithography - In order to avoid the confusion regarding the extent of elaboration of a particular topic a heading should be mentioned with their sub-headings. Such as Sputtering (DC, RF and RF Magnetron sputtering). Epitaxial Growth techniques (Homoepitaxial and Heteroepitaxial growth mechanism)
Section B E-beam lithography: basic principles, e-beam resists; exposure considerations, multilevel techniques. X-ray and ion-beam lithography: basic principles. Imprint lithography: Soft - elastomeric materials ; techniques - near-field phase shift lithography, replica moulding, micromoulding in capillaries, microtransfer moulding, solvent-assisted microcontact moulding, microcontact printing; Rigid -nanocontact moulding; nanoimprint	**Section B** Photolithography, E-beam lithography, X-ray and Ion-beam lithography: Resists and masks, process, types, problem, limitations and way out. Conventional and unconventional lithography, Imprint or soft lithography: Printing/decal transfer, Molding/embossing, Phase-Shift Edge lithography and Nanoskiving (mechanical	Photolithography, E-beam lithography, X-ray and Ion-beam lithography: Resists and masks, process, types, problem, limitations and way out. Imprint or soft lithography: Printing/decal transfer, Molding/embossing, Phase-Shift Edge lithography and Nanoskiving (mechanical sectioning) Scanning probe lithography: Energy transfer: STM and AFM assisted lithography, local oxidation lithography

lithography; UV-assisted - step-and-flash imprint lithography; soft UV nanoimprint lithography; templates, masters and moulds. Scanning probe lithography: scanning probe tools ; techniques - local oxidation nanolithography, local chemical nanolithography, dip-pen nanolithography, hemomechanical patterning and replacement lithography (nanoploughing, nanoshaving and nanografting).	sectioning), Scanning probe lithography: Energy transfer: STM and AFM assisted lithography, local oxidation lithography, Replacement lithography (Nanoshaving, Nanografting and Nanopen reader and writer (NPRW)), and Passive technique: Dip-pen nanolithography, Nanolithography and nanomanipulation.	- There are several techniques belongs to a particular class; all weren't discussed in a given frame of time; but those were need to be discussed which are of remarkable significance. Such as Physical vapour deposition (PVD): Plasma Arc Discharge and Sputtering Replacement lithography (Nanoshaving, Nanografting and Nanopen reader and writer (NPRW)
Section C High Speed Electronic devices (FET, HEMT, pHEMT) and novel concepts. Transferred electronic devices: Gunn devices. Advanced concepts in HBTs. The SiGe and GaN systems: basic band structure and salient features. Circuits: pHEMT and HBT equivalent circuits, frequency dispersion, short channel effects. GaAs and InP Integrated Circuits. Monolithic Microwave Integrated circuits (MMIC). High speed Analogue design. Differential Amplifiers, cascade techniques, direct coupled amplifiers. High speed Operational Amplifiers and Analogue to Digital converters (ADC). Low noise amplifiers. Electronic systems: electronic sources. Frequency multipliers. Heterojunction Barrier varactor (HBV).	**Section C** Metal-semiconductor junctions, Heterojunctions, High Speed electronic devices: FET, MESFET, HEMT, pHEMT and HBT, MESFET, HEMT and HBT equivalent circuits, Heterojunction Barrier varactor (HBV), Transferred electronic devices: Gunn diode, The SiGe and GaN systems: basic band structure and salient features.	- In order to observe the harmonic conductance of a course mutual coherence among the different sections is desired. Such as device section is used to appreciate and understand that "The materials developed from advanced synthesis processes facilitates the development of devices with properties; which otherwise not possible to exist without these techniques". So, the portion of section C which being on not the above proposed ground hence need not to be addressed in section C; is removed.

Books:

1. Introduction to Nanoscience by Gabor L. Hornyak, Joydeep Dutta, H.F. Tibbals, Anil Rao (CRC Press)

2. Molecular Beam Epitaxy by M Henini (Elsevier Store)
3. Microfabrication and Nanomanufacturing By Mark James Jackson.
4. Semiconductor Physics And Devices by Neamen Donald (McGrawHill Education).
5. Introduction to Nanomaterials and Devices by Omar Manasreh (Wiley)

MNEL 2.5 a: MEMS and NEMS Technology

M. Tech. Nanotechnology II Sem.

Existing	Modified	Justification
Section A Introduction to MEMS and NEMS, MEMS Design, Scaling of Micromechanical Devices, Mechanical Properties of MEMS materials, Materials for MEMS, Micromachining Technologies: Bulk, Surface, LIGA, Microfabrication Techniques: Wafer level processes, Pattern Transfer, Process Integration: Developing a process, ~~Basic principles of process design.~~ Transduction Mechanism, Energy conserving transducers: Parallel plate capacitors, two port capacitors, Electrostatic and Magnetic actuators.	**Section A** Introduction to MEMS and NEMS, MEMS Design, Scaling of Micromechanical Devices, Mechanical Properties of MEMS materials, Materials for MEMS, Micromachining Technologies: Bulk, Surface, LIGA, Microfabrication Techniques: Wafer level processes, Pattern Transfer, Process Integration: Developing a process, Transduction Mechanism, Energy conserving transducers: Parallel plate capacitors, two port capacitors, Electrostatic and Magnetic actuators.	-The topic is removed due to repetition.
Section B No change	**Section B** No change	-
Section C No change	**Section C** No change	

Books:

Text Book/Reference Books:

1. Microsystems Design, S. D. Senturia, Kluwer Academic Publishers
2. MEMS Pressure Sensors: Fabrication and Process Optimization, Parvej Ahmad Alvi, (ISBN: 978-84-616-2207-8) Year 2013; IFSA Publication (Barcelona, Spain).
3. The MEMS Handbook, Mohmad Gad-el-Hak, CRC Press
4. Semiconductor Devices: Physics and Technology, S. M. Sze, (Second Ed.) Willey

Annexure-III

B.Sc. V Semester : Physics

Quantum Mechanics and Spectroscopy

Existing Syllabus	Modified Syllabus	Comment
Unit 1 ~~Failures of the classical mechanics~~, black body radiation, Planck's quantum theory, photo electric effect, Einstein's explanation, Compton effect, Ritz combination principle in spectra, Bohr's quantizaion of angular momentum and application to Hydrogen atom, limitations of Bohr theory, Wave - particle duality, de Broglie waves, Electron diffraction experiment, group and phase velocities, uncertainty principle, formulation and its applications, finite size of atom, non existence of electrons in nucleus, Gaussian wave packet, Bohr's principle of complementarity, schrodinger's equation: its need and justification, time dependent and time independent forms, physical significance of wave function (Schrodinger's and Born's interpretation), boundary and continuity conditions of wave function, probability current density.	**Unit 1** Body radiation, Planck's quantum theory, photo electric effect, Einstein's explanation, Compton effect, Ritz combination principle in spectra, Bohr's quantizaion of angular momentum and application to Hydrogen atom, limitations of Bohr theory, Wave - particle duality, de Broglie waves, Electron diffraction experiment, group and phase velocities, uncertainty principle, formulation and its applications, finite size of atom, non existence of electrons in nucleus, Gaussian wave packet, Bohr's principle of complementarity, schrodinger's equation: its need and justification, time dependent and time independent forms, physical significance of wave function (Schrodinger's and Born's interpretation), boundary and continuity conditions of wave function, probability current density.	
Unit 2 No Change	**No Change**	
Unit 3 Application of series solution method to Legendre's ~~Bessel's,~~ Hermite's and ~~Laguerre's~~ differential equations, basic properties like	**Unit 3** Application of series solution method to Legendre's and Hermite's and differential equations, basic properties like – orthogonality, recurrence	

– orthogonality, recurrence relations, graphical representations, generating functions etc. of Legendre's, ~~Bessel's,~~ Hermite's and ~~Laguerre's Associate Legendre's polynomials~~. Bound state problems: Particle in a one-dimensional box - (finite square potential well), Energy eigen values and eigen functions, simple harmonic oscillator (One dimensional case), Zero point energy.	relations, graphical representations, generating functions etc. of Legendre's and Hermite's Polynomials. Bound state problems: Particle in a one-dimensional box - (finite square potential well), Energy eigen values and eigen functions, simple harmonic oscillator (One dimensional case), Zero point energy. Quantum Mechanical States: Ket Bra notation.	
Unit 4 No Change	**No Change**	
Unit 5No Change	**No Change**	

Verified

Offg. Secretary
Banasthali Vidyapith
P.O. Banasthali Vidyapith
Distt. Tonk (Raj.)-304022

Department of Physical Sciences
Banasthali Vidyapith, Banasthali

Minutes of the meeting of Board of Studies held on 26th December, 2018 at 11:00 a.m. in Conference Room, Urja Mandir, Banasthali Vidyapith.

Present

1. Mr. Aavishkar Katti	:	Member
2. Dr. Ajay Singh Verma	:	Member
3. Dr. Banwarilal Chaudhari	:	Member
4. Dr. C.M.S. Negi	:	Member
5. Dr. Devendra Pratap Singh	:	Member
6. Dr. G. Savitha	:	Member
7. Mr. Hemant Kumar	:	Member
8. Mr. Kamal Kumar Jain	:	Member
9. Ms. Lajwanti Singh	:	Member
10. Dr. Madhumita Halder	:	Member
11. Dr. Manish Kumar Srivastava	:	Member
12. Mr. Nishant Singh	:	Member
13. Mr. Pardeep Lamba	:	Member
14. Dr. Parvez Ahmad Alvi	:	Member
15. Ms. Pooja Srivastava	:	Member
16. Ms. Priyanka Saxena	:	Member
17. Mr. Rajnish Kumar	:	Member
18. Dr. Ram Lal Awasthi	:	Member
19. Prof. Ritu Vijay	:	Convener
20. Dr. Sadhu Veera Bhadraiah	:	Member
21. Dr. Saral Kumar Gupta	:	Member
22. Prof. Seema Verma	:	Member
23. Ms. Shalini Jharia	:	Member
24. Mr. Shekhar Yadav	:	Member
25. Ms. Shivani Saxena	:	Member
26. Ms. Sraja	:	Member
27. Dr. Supratim Mitra	:	Member
28. Dr. Sweta Parashar	:	Member

29. Dr. Vartika Kulshreshtha	:	Member
30. Dr. Vishant Gahlaut	:	Member
31. Prof. Rajeev Gupta	:	External Member
32. Prof. Ameer Azam	:	External Member
33. Prof. Sudhish Kumar	:	External Member
34. Prof. Deepak Bhatnagar	:	External Member

Note: Prof. S.C. Bose (External), Dr. Parvendra Tyagi (Internal) could not attend the meeting.

Before proceeding to discuss the agenda of the meeting, convener accorded a cordial welcome to all members who were present in the meeting.

1. BOS took up the confirmation of its last meeting held on 10th March, 2012 and 24th April, 2016 and no comments were received from the members, the Board resolved that the minutes of its last meeting be confirmed.
2. BOS reviewed and updated the existing panel of examiners in each panel of undergraduate and postgraduate examination of Electronics in accordance to the Byelaws 15:03:2002 of the Vidyapith. The list of examiners has been sent to the secrecy.
3. The board reviewed the Study/Curriculum, scheme of examination and proposed revisions in various courses of study as follows:

I. B.Sc. (Mathematics) Examination

i.	First Semester Examination, December, 2019	No Change
ii.	Second Semester Examination, April/May, 2020	No Change
iii.	Third Semester Examination, December, 2020	Minor Change [a]
iv.	Fourth Semester Examination, April/May, 2021	Minor Change [a]
v.	Fifth Semester Examination, December, 2021	Change [a, **b**]
vi.	Sixth Semester Examination, April/May, 2022	Change [a, b]

The Board reviewed the objectives, learning outcomes and existing courses of Electronics running in B.Sc. (Mathematics) programme and no modification in the syllabus was suggested in I year and II year. However board recommended the up gradation in text books and reference books. The list of upgraded text books, reference books and e-resources of the

Electronics courses running in B.Sc. (Mathematics) programme have been enclosed as **annexure I** (Page No 7 -21).

(a) The board proposed to chose at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III, IV, V & VI with prior permission of respective heads, time table permitting.

(b) In III year board proposed to introduce electives in place of discipline courses. **Microprocessors, Communication systems, Introduction to photonics and Antenna Theory and Wave Propagation** have been proposed to include in the discipline electives.

II. B. Tech. (ECE) Examination

i.	First Semester Examination, December, 2019	Minor Change [a]
ii.	Second Semester Examination, April/May, 2020	Minor Change [a]
iii.	Third Semester Examination, December, 2020	Minor Change [a, b]
iv.	Fourth Semester Examination, April/May, 2021	Minor Change [a, b]
v.	Fifth Semester Examination, December, 2021	Revised [a, c]
vi.	Sixth Semester Examination, April/May, 2022	Revised [a, c]
vii.	Seventh Semester Examination, December, 2022	Revised [d, e, f]
viii.	Eighth Semester Examination, April/May, 2023	Revised [g, h, i, j]

Restructuring of the B.Tech. (ECE) scheme has been started from session 2017-18. Scheme and syllabus of I year, II year III year and IV year were presented in front of the board which are enclosed as annexure II (Page No. 22-73).

The following modifications have been recommended for approval:

(a) The board proposed to introduce language courses in I year and incorporate more foundation and vocational courses I year, II year, III year.

(b) The board advised to change the credit from 3 to 4 in *Complex Variables course.*

(c) Upgradation in the syllabus of ***Analog Communication, Analog Electronics, Microwave Engineering, Digital Communication***, ***Control systems*** **for** the **session 2021- 2022** in the curriculum. **Microwave Electronics and Analog integrated circuits** have been renamed as **Microwave Engineering and Analog Electronics**, respectively.

(d) Inclusion of ***Antenna Analysis*** instead of Antenna and Radar course from the session 2022-2023.

(e) The UIL Project is shifted from 7^{th} semester to 8^{th} semester. The change will be applicable from session 2019-20.

(f) Inclusion of *Mechatronics* and *Robotics and Automation* course as discipline electives from the session 2022-2023 in the curriculum keeping in view of interdisciplinary approach of curriculum structure.

(g) Board proposed some new reading electives from the session 2022- 2023 in the curriculum as follows:

- *Telecommunication Switching Systems and Networks*
- *Multimedia Compression and Communication*
- *Electronic Packaging*
- *Professional Ethics.*

(h) Board proposed inclusion of few online courses as reading elective from the **session 2022- 2023** in the curriculum as follows:

- *Electric Vehicles*
- *IoT Sensors and Devices*
- *Electromagnetic Compatibility*.

(i) 3rd year and 4th year of Session 2019 -20 and 2020-21 will be same as session 2021-22 and session 2022-23.

(j) The board advised to introduce open elective in the VII semester. In addition, board proposed to chose at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III, IV, V, VI, and VII with prior permission of respective heads, time table permitting.

III. M.Sc. (Electronics) Examination

i.	First Semester Examination, December, 2019	Revised [a,]
ii.	Second Semester Examination, April/May, 2020	Revised [a, b, c]
iii.	Third Semester Examination, December, 2020	Revised [b,c]
iv.	Fourth Semester Examination, April/May, 2021	Revised [d,e]

The Board reviewed the existing course of M.Sc. (Electronics) examination and recommended change in the scheme and syllabus. **The board also suggested that whenever there is a change or modification in the B.Tech. (ECE) courses, which are common with the M.Sc.(Electronics) Programme, will be affected in the M.Sc. (Electronics) Programme simultaneously.** The changed scheme and syllabus are enclosed as annexure III (Page No. 74-132).

The following modifications have been recommended for approval:

(a) Inclusion of *Signals, Systems and Networks, Semiconductor Devices and Circuits* courses in the curriculum.

(b) Addition of elective course in II semester. Inclusion of Electives in the curriculum as follows:

- *Basics of Nanoelectronics*
- *Mechatronics*
- *Audio and Video Systems*
- *Geoinformatics*
- *Robotics and Automation*
- *Biomedical Instrumentation*
- *Fiber Optics and Communication*
- *Analytical Instrumentation*
- *Digital Signal Processing*
- *Communication Networks*
- *Optical Network*
- *Satellite Communication*
- *Mobile Communication*
- *Radar Navigation*
- *Power Electronics*
- *Antenna Analysis*

(c) Addition of open elective course in III semester. In addition, board proposed to chose at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters II, and III with prior permission of respective heads, time table permitting.

(d) Addition of new reading electives in the curriculum as follows:

- *Telecommunication Switching Systems and Networks*
- *Multimedia Compression and Communication*
- *Electronic Packaging*
- *Professional Ethics.*

(e) Board proposed inclusion of few online courses as reading elective for the session 2020- 2021 in the curriculum as follows:

- *Electric Vehicles*
- *IoT Sensors and Devices*
- *Electromagnetic Compatibility*

IV. M.Tech. (VLSI Design)

i.	First Semester Examination, December, 2019	Revised [a]
ii.	Second Semester Examination, April/May, 2020	Revised [a]
iii.	Third Semester Examination, December, 2020	Revised [b, c]
iv.	Fourth Semester Examination, April/May, 2021	Revised [b, c]

The Board reviewed the existing course of M.Tech. (VLSI Design) and recommended few changes in the list of electives and reading electives. The Board also reviewed the text books and reference books of existing courses of M.Tech. (VLSI Design) and recommended upgradation in text books and reference books. E-resources also have been included for referencing. The board also suggested some of the online courses as reading elective for the programme. The updated syllabus, list of electives and reading electives are enclosed as **annexure IV** (Page No. 133-169).

The following modifications have been recommended for approval:

(a) The board advised to incorporate open elective course in the II semester and include of *Photonics Integrated Circuits* in the list of discipline electives. In addition, board proposed to choose at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters I, and II with prior permission of respective heads, time table permitting. The board also suggested to amend the list of discipline electives.

(b) Addition of *Advanced Electronic Packaging and Compound Semiconductor Technology* in the list of reading electives.

(c) Inclusion of online courses namely *Digital Image Processing and Organic Electronic Devices* as reading electives in the curriculum.

V. B.Sc. (Mathematics)/ B.Sc. (Geology)/B.Sc-B.Ed. Examinations:

i.	First Semester Examination, December, 2019	Revised[(a)]
ii.	Second Semester Examination, April/May, 2020	No Change
iii.	Third Semester Examination, December, 2020	No Change
iv.	Fourth Semester Examination, April/May, 2021	Revised [(b,c)]
v.	Fifth Semester Examination, December, 2021	Change [(d,e,f)]
vi.	Sixth Semester Examination, April/May, 2022	Change[(f)]

The Board reviewed the objectives, syllabi, learning outcomes of the B.Sc. (Mathematics) / B.Sc. (Geology)/B.Sc-B.Ed. programmes.

(a) The board has reframed the experiment list of **Electronics Lab (PHY 104L)** and suggested to add some more experiments relevant to existing syllabus of Physics in first semester.

(b) The board has suggested the name of the course (course code: PHY 203) as **"Thermodynamics, Statistical and Mathematical Physics"** instead of **"Statistical and Mathematical Physics".**

(c) The board has reviewed the experiment list of physics lab (course code: PHY 202L). The board found that some of the experiments are not being matched with the theory taught in the relevant semester and therefore, some modifications have been made in the experiment list.

(d) The board has reviewed the experiment list of physics lab (course code: 5.2). The board found that some of the experiments are not being matched with the theory taught in the relevant semester and therefore, some modifications have been made in the experiment list.

(e) The board has suggested the name of the course (course code: PHY 203) as **"Quantum Mechanics and Spectroscopy"** in place of **"Quantum, Atomic and**

Molecular Physics" and the name of **"Atomic Physics Lab"** changed to **"Quantum Mechanics and Spectroscopy Lab".**

(f) The board has suggested to keep discipline electives and related labs in V and VI semester of the program.

The revised syllabus, course learning outcomes, list of suggested books and e-resources of the B.Sc. (Mathematics) programme is attached and marked as **Annexure-V** (Page No. 170-190).

The corrected name of the courses as well as name of Labs and the contents changed in the revised syllabi should be implemented for the session 2019-20.

VI. B.Sc. (Aviation Science) Examinations:

The course learning outcomes of the course: Basic Physics-I (course code: PHY 102), list of suggested books and e- resources of the B.Sc. (Aviation Science) programme is attached and marked as **Annexure-VI** (Page No. 191).

VII. M.Sc. (Physics) Examinations:

The Board discussed the recent trends in physical sciences at postgraduate level and found that the knowledge of computational software is the necessity of today's research environment. In addition to this, board suggested to give more weight-age to self-learning and independent research activities.

i.	First Semester Examination, December, 2019	Revised[(a)]
ii.	Second Semester Examination, April/May, 2020	Revised[(b)]
iii.	Third Semester Examination, December, 2020	Revised[(c,*)]
iv.	Fourth Semester Examination, April/May, 2021	Revised[(d,*)]

(a) Board reviewed the syllabi of M.Sc. Physics I Semester and found that the courses *Classical Mechanics* (Course Code: PHY 403) and *Mathematical Physics* (Course Code: PHY 404) must be revised. It was found that the content of the course mentioned was not systematic and therefore the board has suggested restructuring the syllabi.

(b) Board reviewed the syllabi of M.Sc. Physics II Semester and found that the courses *Classical Electrodynamics – I* (Course Code: PHY 402) and *Quantum Mechanics* (Course Code: PHY 407) must be revised. The board has suggested minor changes in the course *Classical Electrodynamics – I* (Course Code: PHY 402); while in the *Quantum Mechanics* (Course Code: PHY 407) some mathematical and conceptual details and revision of perturbation theory is required to explain the need of approximation methods.

(c) Board reviewed the syllabi of M.Sc. Physics III Semester and found that the courses *Physics of Lasers and Lasers Applications* (Course Code: PHY 520), *Condensed Matter Physics-I* (Course Code: PHY 505), *Condensed Matter Physics-II* (Course Code: PHY 506) and *Physics Lab - II* (Course Code: PHY 518L) must be revised. It was found that the content of the course mentioned was not systematic and therefore the board has suggested restructuring the courses *Physics of Lasers and Lasers Applications* (Course Code: PHY 520); while the list of the experiments has been divided into two parts: part A and part B instead of three parts. In addition to these changes, the board has also proposed to include **Reading Elective** in the third semester.

(d) Board reviewed the syllabi of M.Sc. Physics IV Semester and no changes were suggested except laboratory practices of physics lab-III (Course code- PHY 519L). The board has suggested that the list of the experiments should be divided into two parts: part A and part B instead of three parts.

(*) Board has proposed new electives in the curricula i.e. **Bio Physics-I** and **Bio Physics-II** in M.Sc. IIIrd and IVth semester respectively.

The specific programme outcome, revised syllabus, course learning outcomes, list of suggested books and e- resources of the M.Sc. (Physics) programme is attached and marked as **Annexure-VII** (Page No. 192-230). The detailed proposed scheme of M.Sc. (Physics) programme is attached as **Annexure VII A** (Page No. 231-236).

The content changed in the revised syllabi should be implemented for the session 2019-20.

VIII. M.Tech. (Nanotechnology) Examinations:

i.	First Semester Examination, December, 2019	Revised$^{(a,*)}$
ii.	Second Semester Examination, April/May, 2020	Revised$^{(*)}$
iii.	Third Semester Examination, December, 2020	No Change
iv.	Fourth Semester Examination, April/May, 2021	No Change

(a) The board has revised the whole syllabus of M.Tech (Nanotechnology) and found that the syllabus of **Nano-photonics and Optoelectronics** course (code: ELE506) should be revised.

(*) Apart from the theory course, the board has also reframed the simulation lab-I and –II (code: NANO 502L & NANO 503L). The revised syllabus is enclosed as **Annexure–VIII** (Page No. 242-256). The detailed proposed scheme of M.Tech. (Nanotechnology) programme is attached as **Annexure VIII A** (Page No. 237-241).

4. The Board reviewed the curriculum for the courses running in the other programmes of the Vidyapith. The recommendations as follows-

Bachelor of Technology (BT/CE/EC/EE/EI/CS/IT/MCTR)		
ENGG 202	Basic Electronics	No Change
Bachelor of Technology (EI)		
VLSI 401	VLSI Design	No Change
ELE 201	Digital Electronics	No Change
ECE 302	Communication Engineering	No Change
Bachelor of Technology (EE/EI/MCTR)		
ELE 201	Digital Electronics	No Change
Master of Science (Physics)		
ELE 406	Principles of Digital Electronics	No Change
Bachelor of Science (Aviation Science)		
PHY 102	Basic Physics-I	No Change
Bachelor of Technology (All Branches)		
PHY 101	Applied Optics	No Change
PHY 105	Engineering Mechanics	No Change
PHY 106	Modern Physics	No Change

5. The board considered the report of examiners of different examinations. Most of the examiners found that the content of the answers were satisfactory or good. The reports are attached as **annexure IX** (Page No. 257).

   The board has reviewed the reports received from the examiners of different examinations and their observations are as follows:

   - reports were satisfactory
   - Performance of the students in most of the papers is up to the mark.
   - The numerical solving ability of the students was found less.

   After observing the reports received from the examiners of different examinations the following suggestions were given:

   - The numerical solving ability of the students is a major concern and therefore, it should be addressed through proper tutorial classes.
   - To give equal weightage for each section (three sections course paper), the number of questions to be attempted compulsorily should be **six** instead of **five**.

6. BOS has thoroughly analysed the quality of the session 2017-2018 question papers keeping the following points in mind

   - Percentage of analytical based question
   - Percentage of descriptive questions
   - Percentage of numerical based questions

   In most of the paper, it has been found that there has been a judicious balance of all these components in the papers.

The board has evaluated the question papers of the periodical and semester examinations and found that the quality of the question papers is maintained at UG and PG level. To improve the standard of the question paper, the board has given following suggestions :

- Include more numerical/logical problems.
- Instead of direct questions and derivations, some small conceptual questions must be put in the question paper to check the analytical ability of the student.

7. **To review the degree title for the Ph.D. Scholars**

Currently Ph.D. degree is awarded in various disciplines namely Electronics, Electronics Engineering, Digital Communication Engineering and many more. To remove the ambiguity it is proposed that the degree title in sciences should be Electronics or Physics and for engineering background, it should be awarded in Electronics Engineering.

The meeting ended with vote of thanks.

Annexure I

Name of Programme: B.Sc. (Mathematics)

Disciplinary Course-Electronics

Programme Educational Objectives:

- To provide necessary knowledge and leadership skills for a successful professional career.
- To enhance learning and to adapt in a world of constantly evolving and innovative electronics technology.
- To develop the ability to collaborate with others to solve problems with creative thinking and effective communication.

Programme Outcomes: On completion of the B.Sc. the student will be able to

- Apply knowledge of mathematics and science.
- Understood the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
- Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.
- Think creatively (divergently and convergent) to propose novel ideas in explaining facts and figures or providing new solution to the problems. Realized how developments in any science subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments.
- Realized that knowledge of subjects in other faculties such as humanities, performing arts, social sciences etc. can have greatly and effectively influence which inspires in evolving new scientific theories and inventions.
- Imbibed ethical, moral and social values in personal and social life leading to highly cultured and civilized personality. Developed various communication skills such as reading, listening, speaking, etc.
- Function with multidisciplinary teams.

Programme Scheme:

B.Sc. (Mathematics) Semester - I (December, 2019)

Disciplinary Course-Electronics

Existing Scheme						**Proposed Scheme**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 102	Circuits and Signals	6	0	0	6	ELE 102	Circuits and Signals	6	0	0	6
ELE 102L	Circuits and Signals Lab	0	0	4	2	ELE 102L	Circuits and Signals Lab	0	0	4	2
Total		6	0	4	8	**Total**		6	0	4	8

B.Sc. (Mathematics) Semester - II (April/May, 2020)

Disciplinary Course-Electronics

Existing Scheme						**Proposed Scheme**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 103	Principles of Electronics	6	0	0	6	ELE 103	Principles of Electronics	6	0	0	6
ELE 103L	Principles of Electronics Lab	0	0	4	2	ELE 103L	Principles of Electronics Lab	0	0	4	2
Total		6	0	4	8	**Total**		6	0	4	8

B.Sc. (Mathematics) Semester - III (December, 2020)

Disciplinary Course-Electronics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 204	Fundamentals of Digital Electronics	6	0	0	6	ELE 204	Fundamentals of Digital Electronics	6	0	0	6
ELE 204L	Fundamentals of Digital Electronics Lab	0	0	4	2	ELE 204L	Fundamentals of Digital Electronics Lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - IV (April/May, 2021)

Disciplinary Course-Electronics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 203	Electronic Instrumentation and Measurements	6	0	0	6	ELE 203	Electronic Instrumentation and Measurements	6	0	0	6
ELE 203L	Electronic Instrumentation and Measurements Lab	0	0	4	2	ELE 203L	Electronic Instrumentation and Measurements Lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - V (December, 2021)

Disciplinary Course-Electronics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 305	Microprocessors	6	0	0	6		Discipline Elective -I	6	0	0	6
ELE 305L	Microprocessors Lab	0	0	4	2		Discipline Elective Lab-I	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - VI (April/May, 2022)

Disciplinary Course-Electronics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 302	Communication Systems	6	0	0	6		Discipline Elective -II	6	0	0	6
ELE 303L	Communication Systems Lab and Project	0	0	4	2		Discipline Elective Lab-II	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

*** L - Lecture hrs/week; T - Tutorial hrs/week;**
P-Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C- Credit Points of the Course

Discipline Elective					
Course Code	**Name of Course**	**L**	**T**	**P**	**C**
ELE 305	Microprocessors	6	0	0	6
ELE 305L	Microprocessors Lab	0	0	4	2
	Introduction to Photonics	6	0	0	6
	Introduction to Photonics Lab	0	0	4	2
ELE 302	Communication Systems	6	0	0	6
ELE 302L	Communication Systems Lab	0	0	4	2
	Antenna Theory and Wave Propagation	6	0	0	6
	Antenna Theory and Wave Propagation Lab	0	0	4	2

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
1.	**ELE 102, Circuits and Signals**	After completion of this course, students will be able to: • Predict the behaviour of any electrical and magnetic circuits. • Formulate and solve complex AC, DC circuits. • Explain response of RL, RC and RLC networks. • Realize the requirement of transformers in transmission and distribution of electric power and other applications.	—	—	**No Change in course contents.**
			Text Book: 1. B.L.Thareja, "A Text Book of Electrical Technology", Vol. I and II, 1994, ISBN-81-219-0515-X	**Recommended Books:** 1. Thareja,B.L.(2005). *A Text Book of Electrical Technology*. New Delhi: S Chand Publication. 2. Chakrabarti, A. (2018).*Circuit Theory Analysis and Synthesis.* New Delhi: Dhanpat Rai & Co. 3. Mehta, V.K. (2005) .*Principles of*	**Added**

				Electrical Engineering. New Delhi: S Chand Publication. **Suggested e-resources:** 1. **Basic Electrical Circuits** by Dr Nagendra Krishnapura, Indian Institute of Technology, Madras. https://nptel.ac.in/courses/117106108/ 2. **Basic Electrical Technology** by Prof. T. K. Bhattacharya, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105053/ 3. **Fundamentals of Electrical Engineering** by Prof.Debapriya Das, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105112/1	
2.	**ELE 102L, Circuits and Signals Lab**	After completion of this laboratory course, students will be able to: • Test Various Active and Passive components using Multimeter and CRO. • Understand frequency response of Resonance. • Verify different Network Theorems.			**Learning Outcomes added.** **No Change in Experiment List.**
3.	**ELE 103, Principles of Electronics**	After completion of this course, students will be able to: • Design various diodes circuits for various applications. • Differentiate various biasing	—	—	**No Change in course contents.**

		methods used in BJTs and FET's • Analysed different kinds of oscillators and feedback circuits.	**Text books:** 1. Millman, Halkias, "Integrated Electronics," TMH Publications 2. Robert Baylsted, "Electronics Devices," PHI Publications **Reference books:** 1. Malvino Leach, "Principle of Electronics," Tata Mg Hills	**Recommended Books:** 1. Parikh, Millman & Halkias. (2017). *Integrated Electronics: Analog & Digital Circuits and Systems*. New Delhi: McGraw Hill Education. 2. Boylestad, Robert L., & Nashelsky Louis. (2015). *Electronic Devices& Circuit Theory*. New Delhi: Pearson Publication. 3. Malvino, Albert., & Bates, David J. (2017) Electronic Principles. New Delhi: McGraw Hill Education. **Suggested E-resources:** **1. Basic Electronics** by Dr. Pramod Agarwal, Indian Institute of Technology, Roorkee. https://nptel.ac.in/courses/117107095/	
4.	**ELE 103L, Principles of Electronics Lab**	After completion of this laboratory course, students will be able to: • Identify and Test various electronics components. • Understand I-V characteristics of various Electronic devices. • Draw frequency response of amplifiers.	**----**	-----	**Learning Outcomes added.** **No Change in Experiment List.**
5.	**ELE 204, Fundamentals of Digital Electronics**	After completion of this course, students will be able to: • Develop a skill to build digital logic circuits, troubleshoot them and apply it to solve real life problems. • Analyze, design and implementation of various combinational and sequential circuits. • Differentiate various logic families. • Understand the operation and application of multi-vibrators.	—	—	**No Change in course contents.**
			Text Books: 1.MANO M.M. "DIGITAL DESIGN", PHI, 2ND EDI. 2. SinghalRajul, "Pulse & Linear Integrated Circuits", Standard Publisher distributor, 1st Edition, 2002. ~~3. Bartee T.C., "Digital Computer~~	**Recommended Books:** 1. Morris Mano, M., & Ciletti, Michael D. (2018).*Digital Design.* New Delhi: Pearson Publication. 2. Singhal, Rajul. (2003). *Pulse & Linear Integrated Circuits*. New Delhi:Standard Publisher distributor. 3. Floyd, Thomas L. (2014). *Digital Fundamentals.* New Delhi: Pearson	

			~~Fundamental ", PHI, 3rd Edition~~ **Reference Books :** 1. Floyd Thomas L., "Digital Fundamental", Pearson Education, 3rd Edition, 2002. 2. ~~SchilingTaub, "Integrated circuits", TMH, 2nd Edition.~~	Publication. **Suggested E-resources:** 1. **Digital Circuits and Systems** by Prof. Srinivasan Department of Electrical Engineering Indian Institute of Technology Madras. https://nptel.ac.in/courses/117106086/ 2. **Digital System Design** by Prof. D. Roy Choudhury Department of Computer Science and Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105080/3.	
6.	**ELE 204L, Fundamentals of Digital Electronics Lab**	After completion of this laboratory course, students will be able to: • Understand the functioning of bread board. • Implement and verify logic gates and theorems. • Design combinational and sequential circuits.	**------**	**-------**	**Learning Outcomes added.** **No Change in Experiment List.**
7.	**ELE 203, Electronic Instrumentation and Measurements**	After completion of this course, students will be able to: • Understand and estimate various types of errors in measurements. • Explain the operating principle of various measuring instruments used to detect physical quantities**.** • Design op-amp circuits and understand SCR operation.	—	—	**No Change in course contents.**
			Text Books : 1. Ramamoorthy M., "An Introduction to Thyristors& their Applications", 2nd Edition, ISBN-81-85336-67-9 2. SawhenyA.K., "A Course of Electrical & Electronic Instrumentation and Measurement Techniques", 11th Edition, 1995, Pub. Dhanpat Rai, New Delhi	**Recommended Books:** 1. Ramamoorthy, M. (1991). *An Introduction to Thyristors& their Applications*. New Delhi: Affiliated East-West Press (Pvt.) Ltd. 2. Sawheny, A.K.(2015). *A Course in Electrical & Electronic Measurements and Instrumentation*. New Delhi: Dhanpat Rai & Co 3. Helfrick Albert D. & Cooper W.D. (2016). *Modern Electronic*	

			References Book: 1. Cooper W.D., "Modern Electronic Instrumentation and Measurement Techniques", 3rd Indian Reprint, Prentice Hall of India Private Limited, 1995	*Instrumentation and Measurement Techniques (1/e).* New Delhi: Pearson Publication. **Suggested E-resources:** 1. **Industrial Instrumentation** by Prof. AlokBarua, Department of Electrical Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105064/7 2. **Analog Circuits** by Prof. Pramod Agarwal**,** Department of Electrical Engineering Indian Institute of Technology**,** Roorkee. https://nptel.ac.in/courses/117107094/1 3. **Basic Electronics** by Prof. T.S. Natarajan, Department of Physics Indian Institute of Technology, Madras. https://nptel.ac.in/courses/122106025/39 **4. Electrical and Electronic Measurements** by Prof. V. Jagdeesh Kumar, Department of Electrical Engineering Indian Institute of Technology, Madras. https://nptel.ac.in/syllabus/108106070/	
8.	**ELE 203L, Electronic Instrumentation and Measurements Lab**	After completion of this laboratory course, students will be able to: • Understand principle of different transducers. • Design various circuits Using Op-Amp IC. • Understand and draw V-I characteristics of SCR, DIAC and TRIAC.	------	------	**Learning Outcomes added.** **No Change in Experiment List.**

9.	**ELE 305, Microprocessors**	After completion of this course, students will be able to: • Describe the general architecture of microcomputer system and architecture & organization of 8085 & 8086 Microprocessor and understand the difference between 8085 and advanced microprocessor. • Distinguish the use of different instructions and apply them in assembly language programming. • Explain and realize the interfacing of memory & various I/O devices with 8085 microprocessor.	—	—	**No Change in course contents.**
			Text Books 1. GaonkerR.S., "Microprocessor Architecture, Programming & Applications with the 8085/8080", 2nd Edition, New Age International Publishers Limited, ISBN-81-224-0710-2. 2. Douglas V. Hall, "Microprocessor and Interfacing", Mc-Graw Hill Book Company, 1987, ISBN-0-07-100462-9 **Reference Books** 1. ~~Short K.L. , "Microprocessor and Programmed Logic", 2nd Edition, Prentice Hall of India Pvt. Ltd. 1988, ISBN-0-87692-515-8.~~ 2. Ram B. , "Fundamentals of Microprocessors and Microcomputer", 5th rev ed., 2001, Dhanpat Rai, New Delhi. 3. ~~Verma Seema, "8085 Microprocessor: Programming, Interfacing and Applications", Aashirvad Publication. Jaipur, 2006~~	**Recommended Books:** 1. Gaonker, R.S. (2013) *Microprocessor Architecture, Programming & Applications with the 8085*. Mumbai, Maharashtra: Penram International Publishing (India) Pvt. Ltd. 2. Douglas V. Hal., SSSP, Rao.(2012) *Microprocessor and Interfacing*. New Delhi: Mc-Graw Hill Publication 3. Ram B. (2018). *Fundamentals of Microprocessors and Microcomputers*. New Delhi: Dhanpat Rai & Co **Suggested E-resources:** 1. **Microprocessor** by Dr. Pramod Agarwal, Department of Electrical Engineering, IITRoorkee https://nptel.ac.in/courses/108107029/ **2. Microprocessors and Microcontrollers** by Prof. Krishna Kumar, IISC Bangalore https://nptel.ac.in/courses/106108100/	~~**Deleted**~~
10.	**ELE 305L, Microprocessors Lab**	After completion of this laboratory course, students will be able to: • Understand the different instructions of 8085 microprocessor assembly language. • Coding in assembly language. • Solve different real time problems.	**----**		**Learning Outcomes added.** **No change in Experiment List.**

11.	**ELE 302, Communication Systems**	After completion of this course, students will be able to: • Explain the working of communication system, Analog Modulation Techniques and their comparative analysis and applications suitability. • To analyse various methods of baseband/band pass Analogue transmission and detection. • To evaluate the performance of analogue communications in the presence of noise. • Explain the working of AM, FM transmitter and receiver.	—	—	**No Change in course contents.**
			Text Books : 1. Kennedy George "Electronics communication system", TMH, 4th edition, 1999 TMH, New Delhi. 2. Gulati R. R. "Monochrome &colour TV" , 1986, Wiley Eastern, New Delhi. **Reference Books :** 1. Shilling Taub , " Communication system" , TMH, 2nd Edition 2. Lathi BP, "Analog & Digital Communication", Oxford University Press 3. Sharma S.P. "Basic radio & TV, TMH", 1983, TMH, New Delhi.	**Recommended Books:** 1. Kennedy, George. (2017) *Electronics communication System*. New Delhi:Mc-Graw Hill Publication. 2. Gulati, R. R. (2011) *Monochrome and colour Television*. New Delhi: New Age International Publication. 3. Shilling, Taub. (2013) *Principles of Communication Systems*. New Delhi: Mc-Graw Hill Publication. 4. Lathi,B.P., Ding, Zhi., & Gupta, Hari Mohan. (2017) *Modern Digital and Analog Communication Systems*. New Delhi: Oxford University Press. 5. Sharma S.P. (2012). *Basic Radio & Television*. New Delhi: Mc-Graw Hill Publication. **Suggested E-resources:** 1. **Analog Communication** by Prof.Goutam Das, G S Sanyal School of Telecommunications, IIT Kharagpur. https://nptel.ac.in/courses/117105143/ 2. **Communication Engineering** by Prof. Surendra Prasad, Dept. of Electrical Engineering, IIT, Delhi. https://nptel.ac.in/courses/117102059/	
12.	**ELE 303L, Communication Systems Lab**	After completion of this laboratory course, students will be able to: • Understand modulation, demodulation waveform and measure modulation index. • Understand the operation of Pulse modulation and demodulation.	1. To study the Amplitude Modulation & Demodulation and measure modulation Index. 2. To study the Single sideband AM using Balanced Modulator. 3. To study the PAM and its Demodulation. 4. To study the PWM and its	**Communication Systems:** 1. To study the Amplitude Modulation & Demodulation and measure modulation Index. 2. To study the Single sideband AM using Balanced Modulator. 3. To study the PAM and its Demodulation.	**Learning Outcomes added.** **No Change in Experiment List.**

		• Familiarized with radio and TV receiver.	Demodulation. 5. To study the PCM and its Demodulation. 6. To study the PPM and its Demodulation. 7. Familiarization with Radio Receiver - Block Diagram. 8. Familiarization with TV Receiver - Block Diagram. Project.	4. To study the PWM and its Demodulation. 5. To study the PCM and its Demodulation. 6. To study the PPM and its Demodulation. 7. Familiarization with Radio Receiver - Block Diagram. 8. Familiarization with TV Receiver - Block Diagram.	
13.	**Antenna Theory and Wave Propagation**	After completion of this course, students will be able to: • Analyze Maxwell's equation in different forms (differential and integral) and apply them to diverse engineering problems. • Examine the phenomena of wave propagation in different media and its interfaces and in applications of microwave engineering. • Recall electromagnetic plane waves. Apply principles of electromagnetic to explain antenna radiation. Explain various antenna parameters. • Explain dipole antennas. Establish mathematical equations for various parameters of thin linear antenna.		**UNIT I** Review of Electromagnetic theory: Cartesian coordinate system, Circular coordinate system, Spherical coordinate system (dot product, cross product, divergence & curl). Maxwell's equations in differential and integral form, Boundary Conditions for Electrostatics and magnetostatics. **UNIT II** Wave equation and its solution, Poynting vector, General Transmission line equation, input impedance, characteristic impedance, Reflection coefficient, standing wave ratio, Practical problems in transmission lines. **UNIT III** Introduction to antennas, network theorems, Antenna characteristics (Radiation pattern, Directivity, Gain, Polarization, Effective aperture, Friis transmission formula), Vector potentials for electric and magnetic current sources. **UNIT IV** Wire antennas: Hetzian and Marconi antenna, Half wave dipole, monopole and loop antenna, Antenna arrays: Linear array, Two element array, Uniform array, Binomial array **UNIT V** Practical antennas: Slot antenna, Horn	

				antenna, Yagi-uda antenna, folded dipole antenna, Helical antenna.	
				Recommended Books: 1. Hyat, W. H. &. Jr. John A. Buck. (2018). *Engineering Electromagnetics, Student edition*. McGraw Hill Education. 2. Liao, S. Y. (1989). *Microwave devices and circuits*. Pearson Education India. 3. Balanis, C. A. (2016). *Antenna theory: analysis and design*. John wiley & sons. 4. Sadiku, M. N., & Kulkarni, S. V. (2015). *Principles of electromagnetics*. Oxford University Press. 5. Kraus, J. D., Marhefka, R. J., & Khan, A. S. (2006). *Antennas and wave propagation*. Tata McGraw-Hill Education. 6. Collin, R. E. (2007). *Foundations for microwave engineering*. John Wiley & Sons.	
14.	**Antenna Theory and Wave Propagation Lab**	After completion of this laboratory course, students will be able to: • Use HFSS tool to design and analysis of antennas. • Design various type of antennas • Measure and analyse radiation pattern of antennas.		1. To design dipole antenna in HFSS 2. Design monopole antenna in HFSS 3. Design horn antenna in HFSS 4. To measure radiation pattern of Horn Antenna 5. To measure radiation pattern of log periodic Antenna 6. To measure radiation pattern of micro strip patch Antenna 7. To measure radiation pattern of YAGI-UDA Antenna.	
15.	**Introduction to Photonics**	After completion of this course, students will be able to: • Explain the light propagation through optical fibers. • Explain the various light sources and optical detectors.		**Unit 1** Introduction, Ray theory, Optical fibers: multimode, single mode, step index, graded index, plastic & glass fibers. Transmission Characteristics of Optical Fibers: Attenuation, Material absorption loss, refractive index profile, Dispersion	

		• Design fiber optic transmitter and receiver system.		(intermodal & intramodal), Dispersion Shifted Fibers, Dispersion Compensating Fiber.	
				Unit 2 Emission and absorption of radiation, Einstein relation, Absorption of radiation, Population inversion, Optical feedback, Threshold condition. Population inversion and threshold, Basic idea of solid state, semiconductors, gas & liquid laser. Basic concept of Q-switching and mode locking.	
				Unit 3 Fiber Structure, Material, Characteristics, Power & Efficiency of Light Emitting Diode. Optical detection principles, quantum efficiency, Responsivity, p-n and p-i-n photo diode, Avalanche photo diodes.	
				Unit 4 Measurements of Fiber Attenuation, Dispersion, Refractive Index Profile, Cut off Wave Length, Numerical Aperture & Diameter. Optical Time Domain Reflectometry (OTDR) Field measurement through optical time domain reflectometry, Laser	
				Unit 5 Laser based systems for measurement of distance, velocity, liquid level. Fibre optic gyroscope, Holography: basic principle and applications.	
				Recommended Books: **1.** Senior, John.M. (2009). *Optical Fiber Communication Principles & Practice***.** New Delhi: PHI Publication. **2.** Keiser, Gerd. (1991). *Optical Fiber Communication***.** New Delhi: McGraw Hill Publication. **3.** Ghatak, A.K. & Thyagarajan, K.	

				(1981). Laser Theory and Applications, 1 edition. Springer	
16.	**Introduction to Photonics Lab**	After completion of this laboratory course, students will be able to: • Understand the characteristics of an optical fiber and LED. • Understand and measure the basic properties of propagation of light in dielectric Optical fibre including losses, attenuation and coupling. • Explain the working of optical power meter and various sensors.		1. To study Analog Link. 2. To study Digital link. 3. To measure Numerical aperture. 4. To study Propagation Loss. 5. To study Bending Loss. 6. To study EYE Pattern. 7. To calculate BER. 8. To study the characteristics of optical source. 9. To study the characteristics of Optical detector.	

Annexure II

Name of Programme: Bachelor of Technology (ECE)

Programme Educational Objectives: The B.Tech. (ECE) programme aims for the holistic development of students through the unique and innovative fivefold educational ideology of Banasthali Vidyapith. Electronics now become the integral part of our lives. As the world continues to rely on Electronics technology, there is a great requirement for those engineers who are able to design, create, and maintain the many products and systems that support electronics technology. Electronics engineers develop innovative technology solutions in a wide range of areas from handheld communications to solar panels; from cardiac pacemakers to autonomous robots; from wireless networks to bio-engineered sensors that detect dangerous pathogens; and intelligent surveillance systems that perform face and motion recognition.
The program aims to deepen the knowledge and skills of the students on the basic concepts and theories that will equip them in their professional work involving analysis, systems implementation, operation, production, and maintenance of the various applications in the field of Electronics and Communications. The curriculum is designed in a way that it will equip students with a solid grasp of mathematical, scientific, and engineering concepts, through classroom education and laboratory exercises. Graduates of the program are expected to develop and use professional skills that facilitate their continued carrier growth well beyond their graduation.

The main objectives of the program are:

- To provide students solid foundation in mathematical and engineering fundamentals required to solve engineering problems and also to pursue advanced studies. This serves them lifelong in their professional domain as well as higher education.
- To develop an ability to integrate fundamental knowledge of basic science, mathematics and engineering to work on complex problems in the field of Electronics and Communication.
- To prepare engineers to work in inter-disciplinary environment, either independently or in a team, and demonstrate leadership qualities.
- Practice the ethics of their profession, consistent with a sense of social responsibility and develop their engineering design, problem–solving skills and aptitude for innovations as they work individually and in multi-disciplinary teams.
- Inculcate a lifelong learning culture.
- To formulate problems and projects and to plan a process for solution.
- Communicate effectively and manage resources skilfully as members and leaders of the profession.
- To prepare competent engineers at various national and international levels.

Programme Outcomes:

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and Electronics engineering to the solution of complex engineering problems.

PO2. **Problem analysis:** Review, Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/development of solutions:** Develop solutions for complex engineering problems and design system components/processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems:** Use scientific and engineering knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage:** Apply appropriate techniques, resources, and modern engineering tools including MATLAB, LabView, Proteus, VHDL, Arduino and related hardware to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society:** Apply reasoning gained by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge for sustainable development.

PO8. **Ethics:** Apply ethical principles and commit to professional ethics responsibilities and norms of the engineering practice.

PO9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary surroundings.

PO10. **Communication Skill:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Scheme:

1. **Highlighted with gray indicates the changed subject/course/credit/modification in syllabus/ new course added.**
2. **Text in white color with black background indicates swapping of course.**

B.Tech. (ECE) Semester - I (December, 2019)

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
BVF 002/ BVF 003	Environment Studies/Indian Heritage	2	0	0	2		General English /सामान्य हिन्दी	2	0	0	2
MATH 103/ MATH 107	Calculus/ Linear Algebra	3	1	0	4		Core Foundation Course - I	2	0	0	2
PHY 101/ PHY 106	Applied Optics/ Modern Physics	3	1	0	4	MATH 103/ MATH 107	Calculus/ Linear Algebra	3	1	0	4
CHEM 101/ BIO 101	Chemistry/ Biology	3	1	0	4	PHY 101/ PHY 106	Applied Optics/ Modern Physics	3	1	0	4
CHE 101/ PHY 105	Thermodynamics/ Engineering Mechanics	3/4	1/0	0	4	CHEM 101/ BIO 101	Chemistry/ Biology	3	1	0	4
CS 109/ EEE 101	Computer Fundamentals and Programming/ Electrical Engineering	4	0	0	4	CHE 101/ PHY 105	Thermodynamics/ Engineering Mechanics	4/3	0/1	0	4
CS 109L/ EEE 101L	Computer Fundamentals and Programming Lab/ Electrical Engineering Lab	0	0	4	2	CS 109/ EEE 101	Computer Fundamentals and Programming/ Electrical Engineering	4	0	0	4
ENGG 101L /ENGG 102L	Engineering Drawing and Graphics Lab/ Measurement Techniques Lab	0	0	6	3	CS 109L/ EEE 101L	Computer Fundamentals and Programming Lab/ Electrical Engineering Lab	0	0	4	2
						ENGG 101L / ENGG 102L	Engineering Drawing and Graphics Lab/ Measurement Techniques Lab	0	0	6	3
	Semester Wise Total	18/19	4/3	10	27		**Semester Wise Total**	21/20	3/4	10	29

B.Tech. (ECE) Semester - II (April/May, 2020)

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
BVF 003/ BVF 002	Indian Heritage/ Environment Studies	2	0	0	2		सामान्य हिन्दी /General English	2	0	0	2
MATH 107 / MATH 103	Linear Algebra/ Calculus	3	1	0	4		Core Foundation Course – II	2	0	0	2
PHY 106 / PHY 101	Modern Physics / Applied Optics	3	1	0	4	MATH 107 / MATH 103	Linear Algebra/ Calculus	3	1	0	4
BIO 101/ CHEM 101	Biology / Chemistry	3	1	0	4	PHY 106 / PHY 101	Modern Physics / Applied Optics	3	1	0	4
PHY 105 / CHE 101	Engineering Mechanics / Thermodynamics	4/3	0/1	0	4	BIO 101/ CHEM 101	Biology / Chemistry	3	1	0	4
EEE 101/ CS 109	Electrical Engineering / Computer Fundamentals and Programming	4	0	0	4	PHY 105 / CHE 101	Engineering Mechanics / Thermodynamics	3/4	1/0	0	4
EEE 101L / CS 109L	Electrical Engineering Lab / Computer Fundamentals and Programming Lab	0	0	4	2	EEE 101/ CS 109	Electrical Engineering / Computer Fundamentals and Programming	4	0	0	4
ENGG 102L / ENGG 101L	Measurement Techniques Lab / Engineering Drawing and Graphics Lab	0	0	6	3	EEE 101L / CS 109L	Electrical Engineering Lab / Computer Fundamentals and Programming Lab	0	0	4	2
						ENGG 102L / ENGG 101L	Measurement Techniques Lab / Engineering Drawing and Graphics Lab	0	0	6	3
	Semester Wise Total	**19/18**	**3/4**	**10**	**27**		**Semester Wise Total**	**20/21**	**4/3**	**10**	**29**

B.Tech. (ECE) Semester - III (December, 2020)

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
BVF 007R	Selected Writings for Self-Study – I	2	0	0	2		Core Foundation Course - III	2	0	0	2
MATH 207 /MATH 208	Complex Variables/ Differential Equations	3/4	0	0	3/4		Elective Foundation Course - I	2	0	0	2
ENGG 201/ ENGG 202	Structure and Properties of Materials/ Basic Electronics	4	0	0	4	MATH 208/ MATH 207	Differential Equations / Complex Variables /	3	1	0	4
MGMT 209/ TSKL 203	Entrepreneurship/ Technical Report Writing	3	0	0	3	ENGG 202 / ENGG 201	Basic Electronics/ Structure and Properties of Materials	4	0	0	4
CS 209	Data Structures	4	0	0	4	CS 209	Data Structures	4	0	0	4
CS 209L	Data Structures Lab	0	0	4	2	CS 209L	Data Structures Lab	0	0	4	2
ECE 201	Signals, Systems and Networks	4	0	0	4	ECE 201	Signals, Systems and Networks	4	0	0	4
ELE 201	Digital Electronics	4	0	0	4	ELE 201	Digital Electronics	4	0	0	4
ELE 201L	Digital Electronics Lab	0	0	2	1	ELE 201L	Digital Electronics Lab	0	0	2	1
	Total	**24/25**	**0**	**6**	**27/28**		**Semester Wise Total**	**23**	**1**	**6**	**27**

B.Tech. (ECE) Semester - IV (April/May, 2021)

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
BVF 008R	Selected Writings for Self-Study – II	2	0	0	2		Core Foundation Course - IV	2	0	0	2
MATH 208/ MATH 207	Differential Equations / Complex Variables	4/3	0	0	4/3		Elective Foundation Course - II	2	0	0	2
ENGG 202 / ENGG 201	Basic Electronics/ Structure and Properties of Materials	4	0	0	4	MATH 207/ MATH 208	Complex Variables / Differential Equations	3	1	0	4
TSKL 203/ MGMT 209	Technical Report Writing/ Entrepreneurship	3	0	0	3	ENGG 201/ ENGG 202	Structure and Properties of Materials / Basic Electronics	4	0	0	4
CS 214	Object Oriented Programming	4	0	0	4	CS 214	Object Oriented Programming	4	0	0	4
CS 214L	Object Oriented Programming Lab	0	0	4	2	CS 214L	Object Oriented Programming Lab	0	0	4	2
ECE 201	Seminar	0	0	2	1	ECE 201S	Seminar	0	0	2	1
ELE 202	Electrical and Electronics Measurements	3	1	0	4	EIE 202	Electrical and Electronics Measurements	4	0	0	4
ELE 202L	Electrical and Electronics Measurements Lab	0	0	2	1	EIE 202L	Electrical and Electronics Measurements Lab	0	0	2	1
ELE 205	Semiconductor Devices and Circuits	4	0	0	4	ELE 205	Semiconductor Devices and Circuits	4	0	0	4
ELE 205L	Semiconductor Devices and Circuits Lab	0	0	2	1	ELE 205L	Semiconductor Devices and Circuits Lab	0	0	2	1
	Total	**24/23**	**1**	**10**	**30/29**		**Semester Wise Total**	**23**	**1**	**10**	**29**

B.Tech. (ECE) Semester - V (December, 2021)

Existing Scheme					Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Principles of Management / Economics for Engineers	3	0	0		Vocational Course - I	2	0	0	2
	Analog Communication	3	1	2		Core Foundation Course-V / Elective Foundation Course - III	2	0	0	2
	Microprocessor and Microcontrollers	3	1	2		Principles of Management/ Economics	3	0	0	3
	~~Analog integrated Circuits~~	4	0	2	ECE 301	Analog Communication	4	0	0	4
	Communication Networks	4	0	0	ELE 306	Microprocessors and Microcontrollers	4	0	0	4
	Microwave Electronics	4	0	2		Analog Electronics	4	0	0	4
	Seminar	0	0	2	ELE 202	Electromagnetic field Theory	4	0	0	4
	Women in Indian Society (WIS) / Parenthood and Family Relationship	3	0	0		Probability and Statistical Methods/ Numerical Methods	3	1	0	4
					ECE 301L	Analog Communication Lab	0	0	2	1
					ELE 306L	Microprocessor and Microcontrollers lab	0	0	2	1
						Analog Electronics Lab	0	0	2	1
	Total	**24**	**2**	**10**		**Semester Wise Total**	**26**	**1**	**6**	**30**
	Total Credits	**31**				**Total Credits**	**30**			

B.Tech. (ECE) Semester - VI (April/May, 2022)

Existing Scheme					Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Economics for Engineers/ Principles of Management	3	0	0		Vocational Course - II	2	0	0	2
	~~Mathematics IV~~	4	0	0		Elective Foundation Course - III/ Core Foundation Course - V	2	0	0	2
	Power Electronics	3	1	2		Economics / Principles of Management	3	0	0	3
	Control Systems	3	1	2		Microwave Engineering	4	0	0	4
	Digital Communication	4	0	2	EIE 302	Control Systems	4	0	0	4
	Digital Signal Processing	4	0	2	ECE 304	Digital Communication	4	0	0	4
	Project	0	0	8		Numerical Methods/Probability and Statistical Methods	3	1	0	4
	Parenthood and Family Relationship / Women in Indian Society (WIS)	3	0	0		Microwave Engineering Lab	0	0	2	1
					EIE 302L	Control Systems Lab	0	0	2	1
					ECE 304L	Digital Communication Lab	0	0	2	1
						Project	0	0	4	2
	Total	**24**	**2**	**16**		**Semester Wise Total**	**22**	**1**	**10**	**28**
	Total Credit	**34**				**Total Credit**	**28**			

B.Tech. (ECE) Semester - VII (December, 2022)

Existing Scheme					Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	UIL Project	20	0	0		Antenna Analysis	4	0	0	4
	Reading Elective	0	0	4	ECE 402	Fiber Optics and Communication	4	0	0	4
					VLSI 401	VLSI Design	4	0	0	4
					ECE 303	Communication Networks	4	0	0	4
						Discipline Elective	4	0	0	4
						Open Elective	4	0	0	4
						Antenna Analysis Lab	0	0	2	1
					VLSI 401L	VLSI Design Lab	0	0	2	1
					ECE 402L	Fiber Optics and Communication Lab	0	0	2	1
	Total	**20**	**0**	**2**		**Semester Wise Total**	**24**	**0**	**6**	**27**
	Total Credit	**22**				**Total Credit**	**27**			

B.Tech. (ECE) Semester - VIII (April/May 2023)

Existing Scheme					Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Antenna & Radar	4	0	0	ECE 407P	UIL Project	0	0	48	24
	Fiber Optics Communication	4	0	2		Reading Elective	0	0	0	2
	VLSI Design	4	0	2						
	Elective I	4	0	0						
	Elective II	4	0	0						
	Total	**20**	**0**	**2**		**Total**	**0**	0	**48**	**26**
	Total Credits			**22**		**Total Credits**				**26**

Course Code	Discipline Electives	Course Code	Discipline Electives	Course Code	Reading Electives
	Biomedical Instrumentation		Geoinformatics		Electronic Packaging
ECE 404	Optical Network		Analytical Instrumentation		Multimedia Compression and Communication
ECE 406	Satellite Communication	ELE 402	Audio and Video Systems		Professional Ethics
ELE 403	Basics of Nano electronics		Robotics and Automation		Electromagnetic Compatibility
ECE 403	Mobile Communication	EEE 304	Power Electronics		Telecommunication Switching Systems and Networks
ECE 405	Radar Navigation		Mechatronics		Electric Vehicles
ELE 304	Digital Signal Processing				IoT Sensors and Devices

Curriculum Structure

B. Tech. –Electronics & Communication

(I Year)											
Semester - I						**Semester - II**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	General English /सामान्य हिन्दी	2	0	0	2		सामान्य हिन्दी /General English	2	0	0	2
	Core Foundation Course - I	2	0	0	2		Core Foundation Course – II	2	0	0	2
MATH 103/ MATH 107	Calculus/ Linear Algebra	3	1	0	4	MATH 107 / MATH 103	Linear Algebra/ Calculus	3	1	0	4
PHY 101/ PHY 106	Applied Optics/ Modern Physics	3	1	0	4	PHY 106 / PHY 101	Modern Physics / Applied Optics	3	1	0	4
CHEM 101/ BIO 101	Chemistry/ Biology	3	1	0	4	BIO 101/ CHEM 101	Biology / Chemistry	3	1	0	4
CHE 101/ PHY 105	Thermodynamics/ Engineering Mechanics	4/3	0/1	0	4	PHY 105 / CHE 101	Engineering Mechanics / Thermodynamics	3/4	1/0	0	4
CS 109/ EEE 101	Computer Fundamentals and Programming/ Electrical Engineering	4	0	0	4	EEE 101/ CS 109	Electrical Engineering / Computer Fundamentals and Programming	4	0	0	4
CS 109L/ EEE 101L	Computer Fundamentals and Programming Lab/ Electrical Engineering Lab	0	0	4	2	EEE 101L / CS 109L	Electrical Engineering Lab / Computer Fundamentals and Programming Lab	0	0	4	2
ENGG 101L / ENGG 102L	Engineering Drawing and Graphics Lab/ Measurement Techniques Lab	0	0	6	3	ENGG 102L / ENGG 101L	Measurement Techniques Lab / Engineering Drawing and Graphics Lab	0	0	6	3
	Semester Wise Total	**21/20**	3/4	**10**	**29**		**Semester Wise Total**	**20/21**	4/3	**10**	**29**
(II Year)											
Semester - III						**Semester - IV**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Core Foundation Course - III	2	0	0	2		Core Foundation Course - IV	2	0	0	2
	Elective Foundation Course - I	2	0	0	2		Elective Foundation Course - II	2	0	0	2
MATH 208/ Math 207	Differential Equations / Complex Variables /	3	1	0	4	Math 207/ MATH 208	Complex Variables / Differential Equations	3	1	0	4
ENGG 202 / ENGG 201	Basic Electronics/ Structure and Properties of Materials	4	0	0	4	ENGG 201/ ENGG 202	Structure and Properties of Materials / Basic Electronics	4	0	0	4
CS209	Data Structures	4	0	0	4	CS 214	Object Oriented Programming	4	0	0	4

CS 209L	Data Structures Lab	0	0	4	2		CS 214L	Object Oriented Programming Lab	0	0	4	2
ECE 201	Signals, Systems and Networks	4	0	0	4		ECE 201S	Seminar	0	0	2	1
ELE 201	Digital Electronics	4	0	0	4		EIE 202	Electrical and Electronics Measurements	4	0	0	4
ELE 201L	Digital Electronics Lab	0	0	2	1		EIE 202L	Electrical and Electronics Measurements Lab	0	0	2	1
							ELE 205	Semiconductor Devices and Circuits	4	0	0	4
							ELE 205L	Semiconductor Devices and Circuits Lab	0	0	2	1
	Semester Wise Total	**23**	**1**	**6**	**27**			**Semester Wise Total**	**23**	**1**	**10**	**29**
(III Year)												
Semester - V							**Semester - VI**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**		**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Vocational Course - I	2	0	0	2			Vocational Course - II	2	0	0	2
	Core Foundation Course-V / Elective Foundation Course - III	2	0	0	2			Elective Foundation Course - III/ Core Foundation Course - V	2	0	0	2
	Principles of Management/ Economics	3	0	0	3			Economics / Principles of Management	3	0	0	3
ECE 301	Analog Communication	4	0	0	4			Microwave Engineering	4	0	0	4
ELE 306	Microprocessors and Microcontrollers	4	0	0	4		EIE 302	Control Systems	4	0	0	4
	Analog Electronics	4	0	0	4		ECE 304	Digital Communication	4	0	0	4
ELE 202	Electromagnetic field Theory	4	0	0	4			Numerical Methods/Probability and Statistical Methods	3	1	0	4
	Probability and Statistical Methods/ Numerical Methods	3	1	0	4			Microwave Engineering Lab	0	0	2	1
ECE 301L	Analog Communication Lab	0	0	2	1		EIE 302L	Control Systems Lab	0	0	2	1
ELE 306L	Microprocessor and Microcontrollers lab	0	0	2	1		ECE 304L	Digital Communication Lab	0	0	2	1
	Analog Electronics Lab	0	0	2	1			Project	0	0	4	2
	Semester Wise Total	**26**	**1**	**6**	**30**			**Semester Wise Total**	**22**	**1**	**10**	**28**

(IV Year)											
Semester – VII						**Semester - VIII**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Antenna Analysis	4	0	0	4	ECE 407P	UIL Project	0	0	48	24
ECE 402	Fiber Optics and Communication	4	0	0	4		Reading Elective	0	0	0	2
VLSI 401	VLSI Design	4	0	0	4						
ECE 303	Communication Networks	4	0	0	4						
	Discipline Elective	4	0	0	4						
	Open Elective	4	0	0	4						
	Antenna Analysis Lab	0	0	2	1						
VLSI 401L	VLSI Design Lab	0	0	2	1						
ECE 402L	Fiber Optics and Communication Lab	0	0	2	1						
	Semester Wise Total	**24**	**0**	**6**	**27**		**Semester Wise Total**	**0**	**0**	**48**	**26**

Course Code	**Discipline Electives**		**Course Code**	**Reading Electives**
	Biomedical Instrumentation	Geoinformatics		Electronic Packaging
ECE 404	Optical Network	Analytical Instrumentation		Multimedia Compression and Communication
ECE 406	Satellite Communication	ELE 402 Audio and Video Systems		Professional Ethics
ELE 403	Basics of Nano electronics	Robotics and Automation		Electromagnetic Compatibility
ECE 403	Mobile Communication	Power Electronics		Telecommunication Switching Systems and Networks
ECE 405	Radar Navigation	Mechatronics		Electric Vehicles
ELE 304	Digital Signal Processing			IoT Sensors and Devices

Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III, IV, V or VI with prior permission of respective heads, time table permitting.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
1.	**ECE 201, Signals, Systems and Networks**	After the completion of course student will be able to: • Analyze linear time invariant system in time and frequency domain • Apply network theorem to analyze the electrical circuit. • Explain two port parameters.	—	—	**No Change in course contents.**
			Suggested Books: 1. V. Oppenheim, A. V. Willsky, S. Hamid Nawab. Signal and Systems. Second Edition, Prentice Hall. 2. M.E. Van Valkenburg. Network Analysis. Third Edition, Prentice Hall India. 3. J. G. Proakis, D. G. Manolakis. Digital Signal Processing. Fourth Edition, Pearson. 4. F. F. Kuo. Network Analysis and Synthesis. Second Edition, John Wiley and Sons.	**Recommended Books:** 1. Oppenheim A. V., A. V. &Nawab S. H. (2015). *Signal and Systems (2/e)*, Boston: Pearson Publication 2. Valkenburg M.E. Van (2015). *Network Analysis (3/e)*. New Delhi: Pearson Publication 3. Proakis J. G. &Manolakis D. G. (2007). *Digital Signal Processing: Principles, Algorithms, and Applications (4/e)*. New Delhi: Pearson Publication 4. Kuo F. F. (2010). *Network Analysis and Synthesis (2/e)*. New Delhi: John Wiley & Sons Publication **Suggested E-resources:** 1. **Circuit Theory** by Prof. S.C. Dutta Roy, Department of Electrical Engineering, Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/108102042/ 2. **Principles of Signals and Systems** by Prof. Aditya K. Jagannatham, Department of Electrical Engineering Indian Institute of Technology, Kanpur. https://nptel.ac.in/courses/108104100	
2	**ELE 201, Digital Electronics**	After completion of this course, students will be able to: • Students will be able to describe and minimize various digital systems. • Students will understand design steps for combinational and sequential circuits. • Students will understand basic	—	—	**No Change in course contents.**
			Suggested Books: 1. M. Morris Mano. Digital Design. Third Edition. Prentice Hall. 2. Charles H. Roth, Larrry N. Kiney. Fundamentals of Logic Design. Sixth Edition, Cengage Learning. 3. D.P. Leach, A. P. Malvino, G. Saha. Digital Principles and Applications. Eighth Edition, McGraw Hill. 4. John F. Wakerly. Digital Design:	**Recommended Books:** 1. M. M. Morris R. & C. Michael D. (2013). *Digital Design (5/e)*. Pearson Publication 2. R. Charles H., JR. & K. Larrry N. (2010). *Fundamentals of Logic Design (6/e)*. Stanford, USA: Cengage Learning 3. Malvino, A. P., & Leach, D. P. & S. Goutam (2014). *Digital Principles and Applications (8/e)*. New Delhi: Tata McGraw Hill Education Private limited.	

		memory architectures and their functionality.	Principles and Practice. Fourth Edition, Pearson. 5. T. C. Bartee. Digital Computer Fundamentals. Sixth Edition. McGraw-Hill. 6. J. P. Hayes. Computer Architecture and Organization. Third Edition, McGraw Hill.	4. W. John F. (2008). *Digital Design: Principles and Practices (4/e).* Pearson Publication 5. B. Thomas C. (1981). *Digital Computer Fundamentals (5/e).*McGraw-Hill Publication 6. Hayes, J. P. (2002). *Computer architecture and organization*. New York, USA: McGraw-Hill Publication **Suggested E-resources:** 1. **Digital Circuits** by Prof.Santanu Chattopadhyay, Department of Electronics and Electrical Communication Engineering, IIT Kharagpur. https://onlinecourses.nptel.ac.in/noc18_ee33/preview **2. Digital Electronic Circuits**by Prof.Goutam Saha, Dept. of Electronics and Electrical Communication Engineering at IIT Kharagpur**.** https://onlinecourses.nptel.ac.in/noc19_ee09/preview 3. **Digital Circuits and Systems**by Prof. S. Srinivasan, Department of Electrical Engineering, Indian Institute of Technology Madras. https://nptel.ac.in/courses/117106086/	
3.	**ELE 201L, Digital Electronics Lab**	After completion of this laboratory course, students will be able to: • Understand the basic digital circuits and to verify their operation. • Explain the elements of digital system abstractions such as digital representations of information, digital logic, Boolean algebra, state elements and finite state machine (FSMs).	**____**	**____**	**Learning Outcomes added** **No change in experiment list.**

		• Create a gate-level implementation of a combinational and sequential logic functions described by a truth table using and/or/inv gates, multiplexers.			
4.	**ENGG 202, Basic Electronics**	After completion of this course, students will be able to: • Understand the fundamental of semiconductors and design semiconductor circuits.. • Understand the different type of diode/ transistors with their responses. • Analyze various types of oscillators available with their utilization.	—	—	**No Change in course contents.**
			Suggested Books: 1. J. Millman, C. Halkias. Integrated Electronics. Second Edition, McGraw Hill. 2. R. L. Boylested. Electronics Devices and Circuit Theory. Tenth Edition, Pearson. ~~3. A. P. Malvino. Electronic Principles. Sixth Edition, McGraw Hill.~~ 4. N. B. Somanatha. Electronics Devices and Applications. First Edition, Prentice Hall India. 5. A. S. Sedra, K. C. Smith. Microelectronics Circuits: Theory and Applications. Seventh Edition, Oxford University Press. 6. B. G. Streetman, S. K. Banerjee. Solid State Electronic Devices. Sixth Edition, Prentice Hall India.	**Recommended Books:** 1. Millman. J, Halkias. C, Parikh. C. (2017). *Integrated Electronics. (2/e).* New Delhi: TMH Publications. 2. Boylestad.R. (2012). *Electronic Devices& Circuits Theory.(6/e).* New Delhi: Pearson Publications. 3. Somanathan B. Nair. (2006). *Electronics Devices and Applications.* New Delhi: Prentice Hall India Learning Private Limited 4. Smith. S.(2008). *Microelectronics Circuits. (5/e).* New Delhi: Oxford press, India. 5. Streetman Ben. G. (2006). *Solid State Electronic Devices (6/e).* New Delhi: PHI Publications. **Suggested E-resources:** **1. Basic Electronics** by Prof. Pramod Agarwal, Department of Electrical Engineering, Indian Institute of Technology, Roorkee. https://nptel.ac.in/courses/117107095/4 **2. Circuits and Electronics by** Anant Agarwal, Massachusetts Institute of Technology: MIT OpenCourseWare. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/video-lectures/6002_l16.pdf	**~~Deleted~~**

5.	**Electrical and Electronics Measurements**	After completion of this course, students will be able to: • Measure various electrical parameters with precision and accuracy. • Select appropriate transducers for measurement of physical parameter. • Use Signal Generator and CRO for appropriate measurement. • Test and troubleshoot electronic circuits using various measuring instruments.	—	—	**No Change in course contents.**
			Suggested Books: 1. A. K. Sawhney. A Course in Electrical and Electronic Measurements and Instrumentation. Eleventh Dhanpat Rai Publication. 2. R.K. Jain. Mechanical and Industrial Measurements. Twelfth Edition, Khanna Publishers. 3. B.C.Nakra, K.K. Chaudhry. Instrumentation, Measurement and Analysis. Third Edition, McGraw Edition. ~~4. E. O. Doebelin.MeasurementSystems:Application and Design. Fourth Edition. McGraw Hill.~~ ~~5. D. P. Eckmann, Industrial Instrumentation. First Edition, CBS Publications.~~ 6. H.S. Kalsi. Electronic Instrumentation. Third Edition, Tata McGraw Hill. 7. S.K. Singh. Industrial Instrumentation and Control. Third Edition, Tata McGraw Hill. ~~8. C. S. Rangan, G. R. Sarma, V. S. V. Mani. Instrumentation: Devices and Systems. Second Edition, McGraw Hill.~~ ~~9. D. V. S. Murthy. Transducers and Instrumentation. Second Edition, Prentice Hall India.~~	**Recommended Books:** 1. SawhneyA.K. (2015). *A Course in Electrical and Electronic Measurements and Instrumentation.* New Delhi: Dhanpat Rai & Co Publication 2. Jain R.K. (2008). *Mechanical and Industrial Measurement.* New Delhi: Khanna Publishers 3. Nakra B.C. & Chaudhry K.K. (2013). *Instrumentation, Measurement and Analysis.* New Delhi: Tata McGraw Hill Publication 4. Kalsi H.S. (2017). *Electronic Instrumentation.* New Delhi: Tata McGraw Hill Publication 5. Singh S.K.(2010). *Industrial Instrumentation and Control.* New Delhi: Tata McGraw Hill Publication **Suggested e-Resource:** **1. Industrial Instrumentation** by Prof. Alok Barua, Department of Electrical Engineering, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105064	**~~Deleted~~**
6.	**Electrical and Electronics Measurements Lab**	After completion of this laboratory course, students will be able to: • Develop an understanding of construction and working of different measuring instruments	~~1. To study behavior of Inductive Sensors and calculate its switching hysteresis.~~ ~~2. To study behavior of Capacitive Sensors and calculate its Reduction factor.~~ ~~3. To study behavior of Magnetic Sensors and plot its response curve.~~ ~~4. To study behaviour of Ultrasonic Sensors and calculate its switching hysteresis.~~	1. To study Hall Effect. 2. To study principle of Thermocouple. 3. To study principle of Load cell. 4. To study principle of Thermistor. 5. To study principle of strain guage. 6. To study Principle of LVDT 7. To study De sauty bridge. 8. To study Wein AC bridge.	**Learning outcomes added.** **~~Deleted~~** **Added**

		• Develop an ability to use measuring instruments and AC and DC bridges for relevant measurement • Select appropriate passive or active transducers for measurement of physical phenomenon.	~~5. To study behaviour of Photo electric sensors and calculate its switching frequency.~~ ~~6. To detect level with the help of Ultrasonic, Photo electric and Capacitive sensors.~~ ~~7. Logic linking of Sensors: OR gate and AND gate.~~ ~~8. To study Wheatstone bridge and find the unknown resistance.~~ **9.** ~~To calculate the frequency and phase with Lissajous figure pattern using DSO.~~	9. To study CRO circuitry in detail.	
7.	**ELE 205, Semiconductor Devices and Circuits**	After completion of this course, students will be able to: • Explain the energy bands, temperature effects, carrier transport of semiconductor devices • Explain the switching times, capacitance of PN junction, bipolar and unipolar transistor behavior and their differences • Analyze the various feedback circuits and design power amplifiers.	—	—	**No Change in course contents.**
			Suggested Books: ~~1. D. A. Neamen, Semiconductor Physics and Devices, fourth edition, McGraw Hill.~~ 2. S. M. Sze. Semiconductor Devices Physics and Technology. Second Edition, Wiley Student Edition. 3. J. Millman, C. Halkias, C. D. Parikh. Integrated electronics. Second Edition, McGraw Hill. 4. A. Sedra, K. Smith. Microelectronic Circuits Theory and Applications. Fifth International Edition, Oxford University Press.	**Recommended Books:** 1. S. Simon. M.(2002), *Semiconductor Devices Physics and Technology (2/e)* , New Jersey, USA: JOHN WILEY & SONS Publication 2. Millman. J, Halkias. C, Parikh. C. (2017). *Integrated Electronics. (2nd ed).* New Delhi: TMH Publications. 3. Streetman Ben. G. (2006). *Solid State Electronic Devices (6th ed)* New Delhi: PHI Publications. 4. Smith. S.(2008). *Microelectronics Circuits. (5th ed).* New Delhi: Oxford press. **Suggested E-Resources:** 1. **Semiconductor Devices and Circuits** by Prof.SanjivSambandan, Department of Instrumentation and Applied Physics, Indian Institute of Science, Bangalore. https://nptel.ac.in/courses/108108112/ **2. Analog Electronic Circuits** byProf. S. C. Dutta Roy, Department of Electrical Engineering Indian Institute of Technology Delhi. https://nptel.ac.in/courses/108102095/	**Added** **~~Deleted~~**
8.	**ELE 205L,**	After completion of this	1. To study the half wave and full wave	1. To study the half wave and full wave	**Learning**

	Semiconductor Devices and Circuits Lab	laboratory course, students will be able to: • Develop understanding of current voltage characteristics of various semiconductor devices. • Design and analyze the various electronic circuits such as amplifiers and oscillators. • Draw output waveforms of various clipper and clamper circuits.	rectifier circuit. 2. Measurement of bipolar junction transistor (BJT) characteristics. 3. Measurement of junction field effect transistors (JFET) characteristics. 4. To measure input and output characteristics and calculate gain of CE amplifier circuit. 5. To measure input and output characteristics and calculate gain of CB amplifier circuit. 6. To study the frequency response of RC coupled amplifier. 7. To study Wien-bridge oscillator circuit. 8. To study Hartley oscillator circuit. 9. To study the effects of negative feedback on the amplifier characteristics. 10. Study of class A push-pull amplifier. 11. Study of class B push-pull amplifier.	rectifier circuit. 2. Measurement of bipolar junction transistor (BJT) characteristics. 3. Measurement of junction field effect transistors (JFET) characteristics. 4. To measure input and output characteristics and calculate gain of CE amplifier circuit. 5. To measure input and output characteristics and calculate gain of CB amplifier circuit. 6. To study the frequency response of RC coupled amplifier. 7. To study Wien-bridge oscillator circuit. 8. To study Hartley oscillator circuit. 9. To study the effects of negative feedback on the amplifier characteristics. 10. Study of class A push-pull amplifier. 11. Study of class B push-pull amplifier. 12. To study clipper and clamper circuits.	**outcomes added.** **Added**
9.	**ECE 201S, Seminar**	After the completion of course student will be able to: • To identify promising new directions of various cutting edge technologies. • Undertake a critical review of the literature. • Deliver well-organized technical presentations and prepare a technical report.	-----	------	**Learning Outcomes added.**
10.	**Analog Communication**	After completion of this course, students will be able to: • Explain different blocks in communication system and how noise affects	**Section-A** ~~Introduction – Communication Process, Source of Information, Channels-Noise, System Noise Source, Noise & Feed- back, Noise Figure, Electromagnetic Spectra. Base band and pass band signals,~~Modulation Process – Need,~~Bandwidth, Requirements- Frequency Spectra of Non-sinusoidal Signals, Analogue vs Digital Communication,~~	**Section-A** Introduction to signals: Size of signals, Classification of signals, Some useful signal operations, Unit impulse function, Signals and vectors, Signal comparison- correlation, Signal representation by orthogonal signal set, Trigonometric Fourier series, Exponential Fourier series Analysis and Transmission of Signals:	Added Shifted ~~Deleted~~

		communication using different parameters. • Distinguish between different amplitude modulation schemes with their advantages, disadvantages and applications and analyse generation and detection of FM signal and comparison between amplitude and angle modulation schemes. • Identify different types of radio receiver circuits	~~Continuous and Discrete Spectra, Band pass System,~~	Fourier transform of some useful signals, Some properties of Fourier Transform, Signal Transmission through linear system, Ideal and practical filters, Signal distortion over a communication channel, Signal energy and energy spectral density, Signal power and power spectral density.	
			Section B Modulation: Amplitude Modulation : Basic Principles, Mathematical Relationships, Frequency Modulation and Phase Modulation – Basic Principles, Mathematical Relationships, Comparison between Amplitude Modulation and Angle Modulation, Spectral Analysis of Different Modulation; Modulators: Amplitude Modulator, Suppressed Carrier DSB Modulator, Balanced Modulator, SSB Modulators: Filter Method, Phase-shift Method & Third Method-ISB Modulators, Vestigial sideband Modulator; Frequency Modulator: Direct &Indirect Method, Narrow band FM, Phase Modulator, Spectral Analysis of these Modulators; Transmitters – AM Transmitter, ~~Low Level and High Level SSB Transmitter,~~ Pilot Carrier – FM Transmitter – Narrow band and Wide band, FM Stereo Transmitter;	**Section- B** Amplitude Modulation: Baseband and carrier communication, Double sideband modulation, Single sideband modulation, Quadrature amplitude modulation, Vestigial sideband modulation, Carrier acquisition, Superheterodyne receiver Angle Modulation: Concept of instantaneous frequency, Bandwidth of angle modulated waves, Generation of FM waves, Demodulation of FM, Interference in angle modulated systems, FM receiver	Added Shifted ~~Deleted~~
			Section C ~~Receiver:- Sensitivity, Selectivity,~~Signal to Noise Ratio, Demodulators – Diode Detector; FM Detectors, ~~Phase Detector- Ratio Detector – Foster – Seelay Discriminator; AM Receiver – (Block Level Treatment) – TRFReceiver,~~Super-heterodyne Receiver,~~Double Super-heterodyne Receiver,~~SSBReceiver,~~Communication Receiver, AGC Circuitry; FM Receiver – FM Stereo Receiver (Block Level) Carrier Shareholding,~~ Capture Effect.	**Section-C** Random Signal and Noise: Gaussian Noise, Bandpass noise and its representation, Noise power, SNR ratio, PSD of white noise. Analog Systems in The Presence of Noise: Baseband system, Double sideband modulation- Suppressed carrier, Single sideband modulation- Suppressed carrier, Amplitude modulation, Angle modulated systems- Phase and Frequency modulation, Optimum preemphasis-deemphasis systems Systems and Noise Calculations: Electrical Noise, Noise Figure, Equivalent Noise Temperature, Cascade Connection of Two-Port Networks, Free-Space Link Calculations	Shifted ~~Deleted~~

			Text Books: 1. ~~George Kennedy: **Electronic Communications Systems:**McGraw Hill.~~ 2. Taub and Schilling: **Principles of communication systems:**McGraw Hill. 3. ~~Martin S Roden: **Analog and digital Communication systems.**~~ 4. ~~Sol Lapatine: **Electronic communication.**~~ 5. ~~Dennis Roody and JhonCoolen: **Electronic communication** Prentice Hall.~~ ~~6. J Dunlop & D G Smith: **Elecommunication Engineering.**~~	**Recommended Books:** 1. Lathi, B.P., Ding, Zhi.,& Gupta, Hari Mohan. (1998). *Modern Digital and Analog Communication Systems*. New Delhi: Oxford University Press 2. Haykin, S. & Moher, M. (2007).*Introduction to Analog and Digital Communication*. New York, United States: John Wiley & Sons. 3. Shilling, D.L., &Taub, H. (2008). *Principles of Communication Systems*. New Delhi: Mc Graw Hill Publication. **Suggested E-Resources:** 1. **Analog Communication** by Prof.Goutam Das, G S Sanyal School of Telecommunications, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105143/	Added ~~Deleted~~
11.	**Analog Communication Lab**	After completion of this laboratory course, students will be able to: • Demonstrate Amplitude modulation and demodulation techniques. • Demonstrate frequency modulation and demodulation technique. • Analyze generation and detection of FM signal and comparison between amplitude and angle modulation schemes. • Compare different modulations and demodulations to recognize the advantages and disadvantages of them. • Identify different radio receiver circuits and	**----**	**-----**	**Learning outcomes added.** **No change in experiment list.**

		role of AGC.			
12.	**ELE 306, Microprocessors and Microcontrollers**	After completion of this course, students will be able to: • Interface memory and different peripherals with Microprocessor and microcontroller • Design and develop the system for real time applications	—	—	**No Change in course contents.**
			Test Books : 1. Kenneth J Ayala, **"The 8051 Micro Controller Architecture, Programming and Applications",** Thomson Publishers, 2nd Edition. 2. D.V.Hall, **"Micro Processor and Interfacing"**, Tata McGraw-Hill. **Reference Book :** 1. Ajay V. Deshmukh, "Microcontrollers - theory applications", Tata McGraw-Hill Companies-2005. 2. Ray and Bhurchandi. "Advanced Micro Processors", Tata McGraw Hill. 3. Kenneth J. Ayala, "The 8086 Micro Processors Architecture, Programming and Applications", Thomson Publishers, 2005. 4. Microcomputer Systems: The 8086/8086 Family: Architecture, Programming and Design, 2nd ed., Liu & Gibson.	**Recommended Books:** 1) Kenneth, J. Ayala.(2004). *The 8051 Micro Controller Architecture, Programming and Applications***.** New Delhi: Cengage Learning Publication 2) Hall, D.V. (2017). *Micro Processor and Interfacing***.** New Delhi: McGraw-Hill Publication. 3) Deshmukh, Ajay V. (2005). *Microcontrollers – Theory and Applications*. New Delhi: McGraw Hill Publication. 4) Ray, A.K., &Bhurchandi, B.H. (2017). *Advanced Micro Processors*. New Delhi: McGraw-Hill Publication. 5) Kenneth, J. Ayala. (2011). *The 8086 Micro Processors Architecture, Programming and Applications*. New Delhi: Prentice Hall India. 6) Liu, Yu Cheng., & Gibson, A. (1985). *Microcomputer Systems: The 8086/8086 Family: Architecture, Programming and Design.* New Delhi: Prentice Hall India. **Suggested E-Resources:** 1. **Microprocessors and Microcontrollers** by Prof.Santanu Chattopadhyay, Department of E&EC Engineering, IIT Kharagpur. https://nptel.ac.in/courses/108105102/ **2. Microprocessors and Microcontrollers** by Prof. Krishna Kumar, IISC Bangalore https://nptel.ac.in/courses/106108100/	
13.	**ELE 306L, Microprocessors and Microcontrollers Lab**	After completion of this laboratory course, students will be able to: • Understand the different instructions of 8086	**----**	**-----**	**Learning Outcomes added.**

		microprocessor assembly language. • Coding in assembly language. • Solve different real time problems.			**No Change in Experiment List.**
14.	**Electromagnetic Field Theory**	After completion of this course, students will be able to: • Apply vector calculus to static electric-magnetic fields in different engineering situations. • Analyze Maxwell's equation in different forms (differential and integral) and apply them to diverse engineering problems. • Examine the phenomena of wave propagation in different media and its interfaces and in applications of microwave engineering.	**Section A** Elements of Vector calculus: Cartesian coordinate system, Circular-Cylindrical coordinate system, Spherical coordinate system (dot product, cross product, divergence & curl). Electrostatics: Electric Flux Density, Coulomb's law, Gauss's law and their applications, Energy in electrostatic fields, capacitance of parallel plate and coaxial cable, Fields in dielectrics, Boundary conditions, dipole, Laplace's and Poisson's equations and their applications.	--	**Entire Course is shifted from 3rd semester to 5th semester** **No Change in course contents**
			Section B Magnetostatics: Ampere's law, Bios wart's law and their applications, Stock's theorem, Energy in magnetic field, Boundary conditions. Maxwell's Equation: - Maxwell's equations in integral & differential form (Gauss's law in electric and magnetic field, Ampere's circuital law, Faraday's law), Maxwell's equations for time varying field.	--	
			Section C Uniform Plane Waves: Wave equation and its solutions, Pointing vector, propagation through various media-free space, conductor & dielectric, Reflection and Refraction in conductors & Dielectrics with normal and oblique incidence, Phase & Group velocity, Skin depth. Transmission Lines: General equation, input impedance, characteristics impedance, Reflection and reflection coefficient, Standing wave ratio, resonant and resonant line impedance matching, Smith chart and its applications, practical problems in transmission lines.	--	

			Suggested Book: 1. William H. Hayt. Engineering Electromagnetics. Eighth Edition, McGraw Hill. 2. E. C. Jordan, K. G. Balmain. Electromagnetic Waves and Radiating Systems. Second Edition, Prentice hall India. 3. J.D. Kraus, D. A. Fleisch. Electromagnetics with Applications. Fifth Edition, McGraw Hill.	**Recommended Books:** 1. William, H. Hayt. (2017). *Engineering Electromagnetics*. New Delhi: McGraw-Hill Publication. 2. Sadiku, Matthew N. O. (2009). *Principles of Electromagnetics*. New Delhi: Oxford University Press. 3. Jordan, E. C., & Balmain, K. G. (2015). *Electromagnetic Waves and Radiating Systems*. New Delhi: Pearson Publication. 4. Kraus, J.D., &Fleisch, D. A. (1992) *Electromagnetics with Applications*, New Delhi: McGraw-Hill Publication. **Suggested E- Resources:** **1. Electromagnetic Fields** by Prof.Harishankar Ramachandran, Indian Institute of Technology, Madras. https://nptel.ac.in/courses/108106073/ **2. Electromagnetic Fields** by Dr RatnajitBhattacharjee, Indian Institute of Technology, Guwahati. https://nptel.ac.in/courses/117103065/ **3. Electromagnetic Theory** by Dr Pradeep Kumar K, Indian Institute of Technology, Kanpur. https://nptel.ac.in/courses/108104087/	**Added**
15.	**Analog Integrated Circuits**	After completion of this course, students will be able to: • Explain the operation and properties of Op-amp. • Explain the design of differential amplifiers, active filters, oscillators, and other linear and non-linear circuits using linear integrated circuits. • Design and analysis	~~**Analog Integrated Circuits**~~ **Section A** ~~**Feedback Amplifiers:** classifications of amplifiers, general feedback structure, properties of negative feedback, feedback topologies, Transfer gain with feedback, General Characteristics of negative feedback amplifiers, input resistance, output resistance. Method of analysis, voltage series and current series feedback, current shunt and voltage shunt feedback.~~ ~~**Power amplifiers:** classification, operation, analysis and design of Class A, Class B, Class-AB, Class C, power dissipation and efficiency calculations, amplifier distortion.~~	**Analog Electronics** **Section A** Operational Amplifier and its applications: BJT differential amplifier: DC and AC analysis, Transfer characteristics, Differential and Common mode gain, Ideal Op-amp, inverting and non-inverting amplifier, offset voltage, offset current, bias current, frequency response, slew rate, CMRR, summing amplifier, differential and instrumentation amplifier, design of integrator and differentiator, logarithmic and anti-logarithmic amplifiers, Active filters.	**Added** Deleted part is shifted to IV sem. Semiconductor devices & Circuits paper Shifted ~~Deleted~~
			Section B	**Section B**	Added

		of single stage, multistage amplifiers and high frequency amplifiers.	**High Frequency Amplifiers :** Hybrid-pi CE transistor model, Hybrid-pi Conductance, Hybrid-pi Capacitances, CE short circuit current gain, current gain with resistive load, single stage CE transistor amplifier response, gain-bandwidth product, **Multistage Amplifiers :** frequency response, Effect of Cascading on bandwidth, RC Coupled amplifier, Low frequency response of an RC coupled stage, Effect of emitter bypass capacitor, High frequency response of two cascaded CE transistor stages, Multistage CE amplifier cascaded at high frequencies.	Op-amp RC oscillator circuits: Wien bridge, Phase shift; square wave & triangular wave generator, voltage controlled oscillator, Phase locked loops: performance factors, Integrated circuit PLL (565) and its applications, Precision rectifier, comparator, Schmitt trigger and 555 IC Timer, Voltage Regulators: Voltage regulator basics, OP-AMP series voltage regulators, adjustable voltage regulators, short circuit protection and fold back current limiting circuits, IC voltage regulators , switching regulators.	Shifted ~~Deleted~~
			Section C **Operational amplifier & its Applications:** BJT Differential Amplifier: DC and AC analysis, transfer characteristics, differential and common modes gain. ideal op-amp, inverting and non-inverting amplifier, offset voltage, offset current, bias current, slew rate, CMMR, design of Integrator and differentiator, summing amplifiers, differential and instrumentation amplifiers, Active filters, OP-AMP RC Oscillator circuits : Wien-Bridge, Phase-Shift, Precision rectifier, comparator, Schmitt trigger, 555 IC timer.	**Section C** High frequency amplifiers: Hybrid –pi CE transistor model, Hybrid –pi conductance, Hybrid –pi capacitances, CE short circuit current gain, Current gain with resistive load, Single stage CE transistor amplifier response, Gain bandwidth product. Multistage Amplifier: Frequency response, Effect of cascading on bandwidth, RC coupled amplifier; Low frequency response of an RC coupled stage, Effect of emitter bypass capacitor.	Added Shifted ~~Deleted~~
			Text Books: 1. Millman and Halkias : Integrated electronics, TMH, 1991. 2. Boylestad, Nashelshy, **Electronic Devices and Circuit Theory,** Pearson publication, Tenth Edition, 2009. 3. GayakwadRamakant A., "OP-AMP & Linear Integrated circuits", New Delhi (Prentice Hall) fourth Edition 2010. **Reference Book :** 1. Adel Sedra& Kenneth Smith, **Microelectronic Circuits Theory and applications" FIFTH edition International version:** Oxford University Press, 2009.	**Recommended Books:** 1. Gayakwad, Ramakant A. (2010). *OP-AMP & Linear Integrated Circuits*. New Delhi: Prentice Hall Publication. 2. Bell, David A. (2011) *Operational Amplifiers and Linear ICs*. New Delhi: Oxford University Press. 3. Parikh, Millman&Halkias. (2010) *Integrated Electronics: Analog & Digital Circuits and Systems*. New Delhi: McGraw Hill Education. 4. Sedra, Adel.,& Smith, Kenneth. (2009).*Microelectronic Circuits Theory and Applications*. New Delhi: Oxford University Press. **Suggested E-Resource:**	

				1. **Analog Electronic Circuits** by Prof. S. C. Dutta Roy, Indian Institute of Technology Delhi. https://nptel.ac.in/courses/108102095/	
16.	**Analog Integrated Circuits Lab**	After completion of this laboratory course, students will be able to: • Design, construct, and analyze the various analog circuits to compare experimental results in the laboratory with theoretical analysis. • Observe the amplitude and frequency responses of common amplification circuits • Construct the desired Electronic design to meet specific requirements.	~~**Analog Integrated Circuits Lab**~~ 1. To design the Astable Multivibrator using 555 2. To design the Monostable Multivibrator using 555 3. To design summer using 741 IC 4. To design Intergrator using 741 IC 5. To design Schmitt Trigger using 741/555 IC 6. To design Differentiator using 741 IC 7. To design peak detector using 741 IC 8. To design scalar using 741 IC 9. To study active filters : LPF, HPF, BPF. 10. To design Voltage to frequency converter. 11. To study phase locked loop. 12. To study frequency shift keying using PLL 565.	**Analog Electronics Lab** 1. To design the Astable Multivibrator using 555 2. To design the Monostable Multivibrator using 555 3. To design summer using 741 IC 4. To design Intergrator using 741 IC 5. To design Schmitt Trigger using 741/555 IC 6. To design Differentiator using 741 IC 7. To design peak detector using 741 IC 8. To design scalar using 741 IC 9. To study active filters: LPF, HPF, BPF. 10. To design Voltage to frequency converter. 11. To study phase locked loop. 12. 12. To study frequency shift keying using PLL 565.	**Learning Outcomes added.** **No Change in Experiment List**
17.	**Digital Communication**	After completion of this course, students will be able to: • Analyse and implement the concept of Probability Theory, Random Variables, Error Control Theory and Information Theory in Digital Communication Systems • Explain the concept of Analog to Digital Conversion, Sampling, Quantization, Pulse Modulation and PCM • Describe and analyse	**Section A** ~~Random variables: Review of probability theory, communications examples, Random variable, Probability Distribution function, probability density function, joint cumulative distribution and probability density, Average value and variance of a random variable, the error function, Gaussian probability density, Rayleigh probability density, central limit theorem.~~ Discrete massages, the concept of amount of information, Entropy, information rate, coding to increase average information per bit - Huffman coding, ~~Lampel-Zivcoding,~~Shannon's theorem, Channel capacity, capacity of a Gaussian channel, Bandwidth S/N trade – off. Errorcontrol coding: Rationale of coding and types of codes, Discrete memory less charnel, some Algebraic concepts -Code efficiency and Hamming bound, linear block codes, Cyclic	**Section A** Introduction to Digital Communications, Sampling Theorem, Pulse amplitude modulation, Pulse code modulation: Uniform and Non- uniform quantization, T1 Carrier System, Differential pulse code modulation, Delta Modulation Line Coding: PSD of various line codes: polar signaling, on-off signaling, bipolar signaling; Pulse shaping: Nyquist criteria for zero ISI, signaling with controlled ISI, Duobinary pulse, Scrambling, Regenerative repeaters.	Added Shifted ~~Deleted~~

		mathematically the Digital Modulation Techniques-ASK, FSK, PSK	codes, Convolution codes, maximum likelihood decoding of convolution codes.		
			Section B Pulse Modulation Systems: Sampling theorem, Generation and demodulation of PAM,~~PWM, PPM~~, Quantization of Signals, Quantization error, PCMCompanding and Multiplexing of PCM Signals, Delta and ~~adaptive delta modulation~~, Bit, Word and Frame Synchronization, Matched filter detection.	**Section B** Digital Modulation Techniques: Various techniques of phase shift, BPSK modulation, spectrum, Bandwidth efficiency, geometrical representation of BPSK modulation, spectrum, Bandwidth efficiency, geometrical representation of ASK, FSK& Minimum shift keying Noise in digital Communication: PCM and CompandedPCM SNR, Matched filter, Calculation of error probability for ASK, ASK, FSK.	
			Section C Digital Modulation Techniques: Various techniques of phase shift, BPSK modulation, spectrum, Bandwidth efficiency, geometrical representation of BPSK modulation, spectrum, Bandwidth efficiency, geometrical representation of ASK, FSK& Minimum shift keying, Calculation of error probability for PSK, ASK, FSK, Application of digital modulation techniques.	**Section C** Information Theory: The concept of amount of information, Entropy, Information rate, Huffman coding, Channel capacity of a discrete memoriless channel, Shannon's Theorem, Channel capacity, capacity of a Gaussian channel, Bandwidth-S/N trade – off. Error control coding: Rationale of coding and types of codes, Discrete memory less charnel, some Algebraic concepts -Code efficiency and Hamming bound, linear block codes, Cyclic codes, Convolution codes, maximum likelihood decoding of convolution codes.	
			Text Books: 1. Simon Haykin: **Digital Communication**: John Wiley and sons 2. Taub and Schilling: **Principles Of Communication System:** Tata McGraw Hill, Second edition. 3. JhonProakis: **Digital Communications:** McGraw Hill. 4. BernadShlar: **Digital Communication:** Pearson Education. 5. K Sam Shanmugam: **Digital and Analog Communication Systems:**Jhon Wiley and Sons. 6. LathiB.P.: **Modern Digital And Analog Communications Systems:** PRISM	**Recommended Books:** 1. Lathi, B.P., Ding, Zhi.,& Gupta, Hari Mohan. (1998). *Modern Digital and Analog Communication Systems*. New Delhi: Oxford University Press 2. Haykin, S. & Moher, M. (2007) *Introduction to Analog and Digital Communication*. New York, United States: John Wiley & Sons. 3. Shilling, D.L., &Taub, H. (2008). *Principles of Communication systems*. New Delhi: Mc-Graw Hill Publication. **Suggested E-Resources:** **1. Digital Communication**by Prof.Bikash Kumar Dey, Department of Electrical	

			Indian *Edition.*	Engineering, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/117101051/	
18.	**Digital Communication Lab**	After completion of this laboratory course, students will be able to: • Understand the concept of Sampling and various Pulse Modulation techniques i.e. Pulse Amplitude Modulation and demodulation, Pulse Position Modulation and demodulation and Pulse Width Modulation and demodulation. • Analyze the behavior of Pulse Code Modulation and demodulation. • Explain the working of Digital Modulation Techniques ie: Amplitude Shift Keying, Phase Shift Keying and Frequency Shift Keying.	----	-----	**Learning Outcomes added.** **No Change in Experiment List.**
19.	**Control Systems**	After completion of this course, students will be able to: • Formulate mathematical model for physical systems and simplify representation of complex systems using reduction techniques.	**Section A** Open loop and closed loop systems, servomechanism, mathematical model of systems, differential equations and transfer functions, Block diagram algebra, signal flow graphs; +ve and -ve feedback effects of feedback, ~~servo- components, DC and AC servomotors, Techogenerators, synchors, stepper motor, op-amp, potentiometer as an error detector; comparison of AC and DC servomechanism.~~	**Section A** Open loop and closed loop systems, servomechanism, mathematical model of systems, differential equations and transfer functions, Block diagram algebra, signal flow graphs; +ve and -ve feedback effects of feedback. Standard test signals, time response of first and second order systems, steady state errors and error constants, Design specifications of second order systems.	**Added** **Shifted** **~~Deleted~~**

		• Use standard test signals to identify performance characteristics of first and second-order systems. • Apply root locus technique for stability analysis. • Analyse performance characteristics of system using Frequency response methods.	**Section B** Standard test signals, time response of first and second order systems, steady state errors and error constants, Design specifications of second order systems, effects of derivative and integral error compensation, PID controller, Design considerations for higher order systems in brief, performance indices. Concept of stability, necessary conditions for stability, Routh Hurwitz stability criterion, relative stability criterion, relative stability in terms of Routh Hurwitz criterion; Root-locus technique.	**Section B** Effects of derivative and integral error compensation, PID controller, Design considerations for higher order systems in brief, performance indices. Concept of stability, necessary conditions for stability, Routh Hurwitz stability criterion, relative stability criterion, relative stability in terms of Routh Hurwitz criterion; Root-locus technique. Correlation between time and frequency response specifications; Frequency domain plots, polar plots.	**Added** **Shifted** ~~**Deleted**~~
			Section C Correlation between time and frequency response specifications; Frequency domain plots, polar plots, Bode plot, log magnitude versus phase plots; Gain-margin, Phase-margin, Nyquist stability criterion; Constant-M and constant-N circles; closed loop frequency response from these. Preliminary considerations of classical design, cascade and feedback compensation, time-domain design using lag, lead and lag lead compensation, frequency domain design using lag.	**Section C** Bode plot, log magnitude versus phase plots; Gain-margin, Phase-margin, Nyquist stability criterion; Constant-M and constant-N circles; closed loop frequency response from these. Preliminary considerations of classical design, cascade and feedback compensation, time-domain design using lag, lead and lag lead compensation, frequency domain design using lag. State Variable model and solution of state equation ofLTI systems.	**Added** **Shifted** ~~**Deleted**~~
			Text/ReferenceBooks: 1. I.J. Nagrath and M. Gopal: **Control System & Engineering 2nd Ed.:** Wiley Eastern Ltd.,1985. 2. Katsushiko Ogata: **Modern Control Engineering 3rd Ed.**: Printice Hall of India Pvt. Ltd., 2001	**Recommended Books:** 1. Nagrath, I. J. (2006). *Control systems engineering*. New Delhi: New Age International. 2. Ogata, K., & Yang, Y. (2002). Modern control engineering (Vol. 4). India: Prentice hall. **Suggested e-resource:** 1. Control System by Prof. S. D. Agashe, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101037/	
20.	**Control Systems Lab**	After completion of this laboratory course, students will be able to: • Understand the	~~1. To study and controlling action using PID controller and calculate the first overshoot temperature and plot the graph.~~ ~~2. To study the DC position controller and~~	1. To study and controlling action using PID controller and calculate the first overshoot temperature and plot the graph. 2. To study the DC position controller and	**Learning Outcomes added.**

		concept of time response and frequency response of any physical system. • Mathematical modeling of physical system to find out of transfer system. • Analyze the stability of system with the help of system response.	~~find out the tachometer gain.~~	find out the tachometer gain. 3. To determine time domain response of a second order systems for step input and obtain performance parameters. 4. To convert transfer function of a system into state space form and vice-versa. 5. To plot root locus diagram of an open loop transfer function and determine range of gain 'k for stability. 6. To plot a Bode diagram of an open loop transfer function. **7.** To draw a Nyquist plot of an open loop transfers function and examine the stability of the system.	**~~Deleted~~** **Added**
21.	**Communication Networks**	After completion of this course, students will be able to: • Recognize and describe about the working of Computer Networks. • Illustrate reference models with layers, protocols and interfaces. • Combine and distinguish functionalities of different Layers. • Model the LAN and WAN configuration using different media	**Section A** Introduction to communication systems and data communications. Introduction of network, requirement of Internet. Data Networking, Network history, Local area network topologies, WAN, MAN, VPN, (Virtual Private Network). Bandwidth, Bandwidth data rate. Multiplexing-TDM, FDM, CDMA, data encoding. Network model-layer structure of network model. OSI Model, OSI layers. TCP/IP Model layers. Arpanet, Peer to Peer communication. Communication Media and cable-structure-through wire-copper cable-STP, UTP, co-axial cable, optical fiber. Wireless media-wireless LAN, organization and standards. Wireless devices and topologies. Wireless communication, wireless security.	--	**Entire Course is shifted from 5th semester to 6th semester.** **No change in course contents.**
			Section B Network layer devices-Modem, NIC, hub, bridge, switch, router, firewall, gateway. Switching Networks-circuit switching, Packet Switching. Networks-Circuit Switching, Packet Switching. Networks addressing schemes-MAC Address, Subneting, Superneting. Routing Concept, Routing protocol (RIP), Routed protocols. Introduction to IPV6 Principles of Internetworking. Ethernet (CSMA/CD)	--	

			Token Ring and FDDI, Fast Ethernet.		
			Section C Layer protocol Structure. Data link control – Flow Control, Error Detection, Error Control. HDLC. Network layer-ARP, RARP, ICMP. Effect of Congestion and Congestion Control in Network-(Back pressure, choke packet, Implicit Congestion Signaling, Explicit Congestion Signaling. Traffic Management-Transport layer Protocols-connection oriented and connectionless services, TCP, TCP Congestion Control and Flow Control. UDP. Application Layer Protocols – HTTP, FTP, SMTP, SNMP, Telnet. Introduction to ISDN. Narrow Band and Broad Band. Introduction to WAN Technologies. ATM and Frame relay.	--	
			Text Books: 1. E.C. Jordan: **Electromagnetic wave & Radiating System:** PHI, II edition 1986. 2. A.S. Tannanbaum: **Computer Networks:** Pearson Education 2003. 3. W.Stailling: **Data & Computer Communication**: PHI New Delhi, 5th edition 1997. 4. J. Martin: **Computer Networks and Distributed Processing**: PHI, 1998.	**Recommended Books:** 1. Jordan, E.C.(1986). *Electromagnetic Wave & Radiating System*. New Delhi: PHI Publication. 2. Tanenbaum, A.S. (1997). *Computer Networks*. New Delhi: Pearson Publication. 3. Stailling, W. (1997). *Data & Computer Communication*. New Delhi: PHI Publication. 4. Martin, J. (1998). *Computer Networks and Distributed Processing Software, Techniques, Architecture*. New Delhi: PHI Publication. **Suggested E-Resources:** 1. **Computer Networks and Internet Protocol** by Prof.SoumyaKanti Ghosh Department of Computer Science and Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/106105183/ 2. **Computer Networks** by Prof. Sujoy Ghosh, Department of Computer Science and Technology, IIT KG. https://nptel.ac.in/courses/106105081/ 3. **Computer Networks** by Prof. Hema A	

				Murthy, IIT Madras. https://nptel.ac.in/courses/106106091/ 4. **Data Communication** by Prof.Ajit Pal, IIT KG. https://freevideolectures.com/course/2278/data-communication	
22.	**Microwave Electronics**	After completion of this course, students will be able to: • Understand various parameters of waveguide and use of component as per applications • Design impedance matching network for any transmission line or system • Analyse and find applications and limitations of microwave Semiconductor devices. • Find various applications of microwave engineering in specific area	~~**Microwave Electronics**~~ **Section A** Introduction to Microwaves & its application, Transmission lines: General equation, input impedance, characteristic impedance, reflection and transmission coefficient, standing wave ratio, resonant and anti resonant line impedance matching, ~~smith chart and its applications~~, coaxial, ~~twin~~, strip &microstrip lines &baluns	**Microwave Engineering** **Section A** Introduction to Microwaves & its application, Microwave Electromagnetic spectrum, Transmission Lines: General equation, input impedance, characteristic impedance, reflection and transmission coefficient, standing wave ratio, resonant and anti-resonant line impedance matching, Matching techniques: single stub, double stub using smith chart, quarter wave transformer,baluns, coaxial transmission line, Planar transmission line: Strip line, Microstrip line, Slot line etc.	Added Shifted ~~Deleted~~
			Section B Wave Guides: Wave propagation in rectangular & circular wave guides, wave guide modes~~, Q of wave guide~~, Wave guide coupling, Microwave passive components: S-parameter representation and analysis of microwave components such as Waveguide Tees, Two-hole directional coupler, attenuators, Phase shifters, Rectangular cavity resonator, Isolators, Circulators.	**Section B** Wave Guides: Wave propagation in rectangular wave guide: solution of TE and TM modes, Power Transmission and Attenuation, Excitation of modes in Rectangular waveguide, Circular Waveguide: Basic idea of TE and TM modes, Rectangular and Circular cavity resonators, Rectangular cavity resonators, Q of cavity resonators, S parameters and its conversion with Z and Y parameters, Wave guide coupling, Microwave passive Components: S- parameter representation and analysis of microwave components such as Waveguide Tees, Two-hole directional coupler, attenuators, Phase shifters, Microwave propagation in ferrites: Faraday rotation, Isolators, Circulators.	Added Shifted ~~Deleted~~
			Section C Microwave Tube Devices: Conventional Vacuum tubes at microwave, O type device - Klystron (two cavity & reflex). M type device magnetron, Introduction to TWT (Traveling Wave Tubes). Microwave	**Section C** Microwave Tubes: Limitations of Conventional vacuum tubes at microwave, Klystron: Construction and operation of two cavity and multi-cavity klystrons, Applegate Diagram and application of two	Added Shifted ~~Deleted~~

			Semiconductor Devices IMPATT, TRAPATT& Gunn Devices.	cavity klystron, Construction and working of Reflex klystron, Magnetron: Types of magnetron, Construction, Operation and Analysis of cavity or travelling wave magnetron, Traveling wave tubes (TWT): Construction, Operation and practical consideration of helical type TWT, Applications of TWT, Microwave Semiconductor Devices: Tunnel diodes, principle of operation and application of tunnel diodes, Transferred Electron devices: Gunn-Effect diodes, Two-valley theory, Mode of operations of Gunn diode, Avalanche Transit-Time devices: IMPATT, TRAPATT.	
			Text Books: 1. Sisodia-Raghuvanshi: **Microwave Circuits & Passive Devices:** (Wiley-eastern).1st edition.1987 2. S.Y. Liao: **Microwave Devices & Circuits**, (Prentice Hall).1st Edition 1995, 3. Collins: **Foundation Of Microwave Engineering**, (Mc Graw Hill) 2nd Edition 1992 4. P.A. Rizzi: **Microwave:** (Prentice Hall). 1st Edition 1998	**Recommended Books:** 1. Liao, S.Y. (1995). *Microwave devices & Circuits*. New Delhi: Prentice Hall Publication. 2. Rizzi, P.A. (1998). *Microwave Engineering*. New Delhi: Prentice Hall Publication. 3. Collins, R. E. (1992). *Foundation of Microwave Engineering*. New Delhi:McGraw Hill Publication. 4. Pozar, David M. (2008). *Microwave Engineering*. New Delhi: Wiley Publication. **Suggested E- Recourses:** 1. **Microwave Theory and Techniques** by Prof. Girish Kumar, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101112/ 2. **Basic Building Blocks of Microwave Engineering** by Dr Amitabha Bhattacharya, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105130/ **3. Transmission Lines and E.M. Waves** by Prof. R. K. Shivgaonkar, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/117101056/	
23.	**Microwave**	After completion of this	~~**Microwave Electronics Lab**~~	**Microwave Engineering Lab**	**Learning**

	Electronics Lab	laboratory course, students will be able to: • Understand the concept and working of microwave bench and different components connected on a bench. • Analyze the behaviour of various microwave components. • Verify properties/ characteristic of microwave source, tees and directional coupler.	1. Determine the operating frequency of reflex klystron. 2. Draw the V-I characteristics of Reflex klystron 3. Draw the characteristics of attenuator 4. To verify the wave-guide law 5. To study the directivity and coupling coefficient of Directional Coupler. 6. To study the properties of magic Tea and also determine isolation and coupling coefficient. 7. To Measure the VSWR of (i) Short circuit (ii) Open circuit (iii) Matched Load (iv) Unmatched Load. ~~8.~~ To study the properties of E-plane and H-plane Tea. Determine isolation and coupling coefficient	1. Determine the operating frequency of reflex klystron. 2. Draw the V-I characteristics of Reflex klystron 3. Draw the characteristics of attenuator 4. To verify the wave-guide law 5. To study the directivity and coupling coefficient of Directional Coupler. 6. To study the properties of magic Tea and also determine isolation and coupling coefficient. 7. To Measure the VSWR of (i) Short circuit (ii) Open circuit (iii) Matched Load (iv) Unmatched Load. 8. To study the properties of E-plane and H-plane Tea. Determine isolation and coupling coefficient	**Outcomes added.** **No Change in Experiment List**
24.	**Project**	After completion of this course, students will be able to: • Demonstrate effective project execution and control techniques that result in successful projects. • Ability to identify, formulates, and solves engineering problems. • Use the techniques, skills and modern engineering tools necessary for engineering practice.	**-------**	**-----**	**Learning Outcomes Added and this course has no prescribed syllabus**
25.	**Antenna and Radar**	After completion of this course, students will be able to: • Recall electromagnetic plane waves. Apply principles of electromagnetic to explain antenna radiation. Explain	**~~Antenna and Radar~~** **Section A** Introduction to antennas, network theorems, directional properties of dipole antennas,travelling wave antenna& effect of point of feed on standing wave antenna, two element array, linear array, multiplication of patterns, effect of earth on vertical patterns, binomial array, antenna gain, effective area, antenna terminal impedance, ~~antenna as~~	**Antenna Analysis** **Section A** Introduction to antenna, Radiation Mechanism,Current Distribution on a Thin Wire Antenna Fundamental parameters of antenna: Radiation pattern, Radiation power density, Radiation intensity, Beamwidth, Directivity,Antenna efficiency, Gain, Beam efficiency, Bandwidth, Polarization, Input	Added Shifted ~~Deleted~~

		various antenna parameters. • Explain antenna as a point source. Design antenna patterns for different cases. • Explain dipole antennas. Establish mathematical equations for various parameters of thin linear antenna. • Explain loop, slot, patch and horn antennas. Derive expressions for the parameters of loop and slot antennas.	~~spread out transmission line, transmission loss between antenna~~	impedance, Antenna radiation efficiency, Antenna vector effective length, Maximum directivity and Maximum effective area, Friss transmission equation and radar range equation	
			Section B Practical antennas: Hertz and Marconi antenna, antenna losses, effect of antenna height, electrically short antennas, wave antenna, Medium and high frequency antenna, half wave dipole or dipole antenna, ~~harmonic,~~rhombic, V, inverted V, traveling wave antenna, loop antennas, folded dipole, yagi-uda, horn, ~~biconical,~~ helical~~, slot, notch,~~frequency independent and microwave antennas, ~~Antenna measurements.~~	**Section B** Radiation Integrals and Auxiliary Potential Functions: The Vector Potential A for an Electric Current Source J, The Vector Potential F for a Magnetic Current Source M, Electric and Magnetic Fields for Electric (J) and Magnetic (M) Current Sources, Solution of the Inhomogeneous Vector Potential Wave Equation, Far-field radiation, Duality theorem, Reciprocity and Reaction theorem, Image Theory Linear wire antennas: Infinitesimal dipole, Small dipole, Region separation, Finite length dipole, Half-wave dipole Loop Antennas: Small circular loop, Square loop	Added Shifted ~~Deleted~~
			Section C ~~Radio-wave propagation, phenomena and problems encountered in practice: effect of earth and atmosphere in radio waves. Physical principles & basic equations of radar, pulsed, continuous wave and pulsed Doppler radar, antenna systems, transmitters, detection theory, waveform considerations including pulse compression, principle of synthetic aperture radar, propagation clutter, and airborne radar~~	**Section C** Introduction to Arrays, two-element array, N-element linear array: uniform amplitude and spacing, directivity,N-element linear array: uniform spacing, non-uniform amplitude Traveling wave antennas: Long wire antenna, V-antenna, Rhombic antenna Broadband antennas: Helical antenna, Folded dipole, Yagi-uda array of linear elements Log-periodic antenna, Introduction to Horn antenna: E-plane sectoral horn, H-plane sectoral horn, Pyramidal horn	Added Shifted ~~Deleted~~
			References*:* 1. John D. Kraus: **Electromagnetic:** Mc Graw Hill. 2. William, Hayt: **Electromagnetic Engineering:** Mc Graw Hill. 3. Jordan & Balmain: **Electromagnetic Fields & Radiation Systems**: PHI. 4. Sadiku: **Elements of**	**Recommended Books:** 1. Balanis, C. A. (2005). *Antenna Theory Analysis and Design*. New Delhi: John Wiley & Sons. 2. Eliott, Robert S. (2003). *Antenna Theory and Design*. New Delhi: Wiley-IEEE Press. 3. Kraus, J. D., &Marhefka, R. H. (2001). *Antennas for All Applications*, Singapore: McGraw-Hill Publication.	

			Electromagnetic: Oxford University Press. 5. Merrill. I. Skolnik: **Introduction to Radar Systems**, 3rd Ed., Mc-Graw-Hill. 6. Merrill. I. Skolnik: **Radar Handbook:** 2nd Ed., Mc-Graw-Hill, 1990. 7. K. D. Prasad: **Antenna and Wave Propagation**.	4. Harrington, R. F. (2001). *Time-Harmonic Electromagnetic Fields*. New Delhi: Wiley-IEEE Press. **Suggested E- resources:** 1. **Advanced Antenna Theory** by Dr Amalendu Patnaik, Indian Institute of Technology, Roorkee. https://nptel.ac.in/courses/117107035/ 2. **Analysis and Design Principles of Microwave Antennas** by Prof.Amitabha Bhattacharya, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105114/ **3. Antennas** by Prof. Girish Kumar, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101092/	
26.	**Antenna Analysis Lab**	After completion of this laboratory course, students will be able to: • Use HFSS tool to design and analysis of antennas. • Design various type of antennas • Measure and analyse radiation pattern of antennas.	------	1. To design dipole antenna in HFSS 2. Design monopole antenna in HFSS 3. Design horn antenna in HFSS 4. To measure radiation pattern of Horn Antenna 5. To measure radiation pattern of log periodic Antenna 6. To measure radiation pattern of micro strip patch Antenna **7.** To measure radiation pattern of YAGI-UDA Antenna.	**Addition of new Lab.**
27.	**VLSI Design**	After completion of this course, students will be able to: • Explain the basic theory of crystal growth, wafer fabrication and IC fabrication technology. • Explain the different VLSI design styles, overview of ICs and fabrication steps of MOS, CMOS and BJT.	**Section A** Recapitulation of basics, semiconductor devices, orientation effect, impurities, defects, Fabrication: Crystal growth & wafer preparation, Epitaxial growth, oxidation, photo-lithography, etching technology (wet & dry), Diffusion Fick's law, chemical vapor deposition, CVD reactors, ion implantation, metallization & patterning, photo resistive material, packaging.	—	**Course is shifted from 8th semester to 7th semester.** **No change in course contents.**
			Section B Overview of VLSI methodologies, VLSI design flow, type of ICs (monolithic, thick film, thin film, hybrid), Fabrication steps involve in, different type of resisters,	----	

		• Design and analyse the output characteristics of different MOS inverters • Design combinational and sequential circuit.	capacitor, diode, transistor (Darlington etc), JFET, MOSFET, isolation technique used in fabrication, fabrication of typical circuits.		
			Section C Digital CMOs circuit, MOS devices, V-I characteristics, Design & detailed analysis of MOS inverters (resistive load, enhancement load, depletion load, CMOS), delay & power analysis, Design layout of simple CMOS gates. Circuit implementation of combinational circuit, circuit implementation of sequential circuits - FFs, SRAM, DRAM.	--	
			Text Books: 1. Sze S.M.: **VLSI Technology:**TMH. 2. Kang S.M., Leblebici Y: **CMOS digital Integrated Circuits: Analysis &Design** : Mc. Graw Hill. **Reference Books:** 1. Botker B.R: **Microelectronics.** 2. Gandhi S.K.: **VLSI Fabrication Principle.** 3. Plummer J., Deal M., Griffin P.: **Silicon VLSI Technology**: Prentice Hall. 4. Sarrafazadeh M. & Wong C.K.: **An introduction to VLSI Physical Design:** Mc Graw Hill. 5. Martin Ken: **Digital Integrated Circuits:** Oxford press. 6. Neil H.E. Weste& Kamran Eshraghian: **Principle of CMOS VLSI Design.**	**Recommended Books:** 1. *Sze, S.M.(2017). VLSI Technology*. New Delhi*: TMH Publications.* 2. Kang, S.M., &Leblebici, Y. (2002). *CMOS digital Integrated Circuits Analysis & Design*. New Delhi: McGraw Hill Publications. 3. Botkar, K. R. (2004). *Integrated Circuits*. New Delhi: Khanna Publishers. 4. Gandhi, S.K. (1994). *VLSI Fabrication Principle Silicon and Gallium Arsenide*. New Delhi: Willey Publications. 5. Plummer, J., Deal, M., & Griffin, P. (2000). *Silicon VLSI Technology: Fundamentals, Practice and Modeling*. New Delhi: Pearson Publications. 5. Sarrafazadeh, M.,& Wong, C.K. (1996). *An introduction to VLSI Physical Design*. New Delhi: McGraw Hill Publication. 7. Ken, Martin. (1999). *Digital Integrated Circuits Design.* New York, United State: Oxford University Press. 8. Neil, H.E., Weste, &Eshraghian, Kamran (1994). *Principle of CMOS VLSI Design*. Boston, New York: Addison Wesley Publication. **Suggested E-Resources:** 1. **VLSI Circuits** by Prof. S. Srinivasan,	

				Department of Electrical Engineering, IIT-Madras. https://nptel.ac.in/courses/117106092/1 2. **VLSI Technology** by Dr. Nandita Das Gupta, Department of Electrical Engineering, IIT-Madras. https://nptel.ac.in/courses/117101058/	
28.	**VLSI Design Lab**	After completion of this laboratory course, students will be able to: • Use VHDL for design of digital circuits • Model complex digital systems at several level of abstractions; behavioral and structural, synthesis and rapid system prototyping. • Develop and simulate register-level models of hierarchical digital systems	~~**Silvaco**~~ ~~1. Model the fabrication process flow of NMOS with I/V characteristics curve~~ ~~2. Model the fabrication process flow of PMOS with I/V characteristics curve~~ ~~3. Model the fabrication process flow of NPN/PNP mos based transistor with input/output characteristics curve.~~ ~~4. Model the fabrication process flow of pn junction diode.~~	1. Write a program for the implementation of half adder and Full adder. 2. Write a program for implementing half subtractor and full subtractor. 3. Write a program for implementing MUX 4x1 and DEMUX (1X4) 4. Write a program for implementing Encoder and Decoder. 5. Write a program to implement gray code to binary code converter and vice versa. 6. Write a program to implement COMPARATOR. 7. Write a program for the implementation of S-R Flip flop and D Flip flop. 8. Write a program for the implement up-counter and down-counter. 9. Write a program to design JK Flip-flop and write design summary 10. Write a program to design T Flip-flop and write design summary	**Learning Outcomes added.** **Added**
29.	**Fiber Optics and Communication**	After completion of this course, students will be able to: • Explain the light propagation through optical fibers. • Explain the various light sources and optical detectors. • Design fiber optic transmitter and receiver system.		--	**No change in course contents.**
			Text Books: 1. Govind P. Agarwal: **Fiber-Optic Communication Systems:** Wiley India, 3rd Ed.2007. 2. John M. Senior: **Optical Fiber communication:** PHI. **References:** ~~1. D.C. Agrawal: **Fiber Optic Communication**: Wheeler Pub.2nd ed., 1993.~~ 2. ~~Gowar: **Optical Fiber Communication:**~~	**Recommended Books:** **1.** Agarwal, Govind. P. (2007). *Fiber-Optic Communication Systems***.** New Delhi: Wiley India. **2.** Senior, John.M. (2009). *Optical Fiber Communication Principles & Practice***.** New Delhi: PHI Publication. **3.** Bhattacharya, Pallab. (2002). *Semiconductor Optoelectronics Devices***.** New Delhi: PHI Publication. **4.** Keiser, Gerd. (1991). *Optical Fiber Communication***.** New Delhi: McGraw	~~**Deleted**~~

			~~PHI, 1995~~. 3. Pallab Bhattacharya: **Semiconductor Optoelectronics Devices:** PHI 2nd ed., 2002. 4. Gerd Keiser: **Optical Fiber communication:** McGraw Hill, 2nd ed., 1991.	Hill Publication.	
30.	**Fiber Optics and Communication Lab**	After completion of this laboratory course, students will be able to: • Understand the characteristics of an optical fiber and LED. • Understand and measure the basic properties of propagation of light in dielectric optical fibre including losses, attenuation and coupling. • Explain the working of optical power meter and various sensors**.**	**-----**	**------**	**Learning Outcomes added.** **No change in experiment list.**
31.	UIL Project	After completion of this course, students will be able to: • Undertake problem identification, formulation and solution. • Design engineering solutions to complex problems utilizing a systems approach. • Demonstrate the knowledge, skills and attitudes of a professional engineer. • Demonstrate effective organizational leadership and change	**------**	**------**	**Learning Outcomes Added and this course has no prescribed syllabus**

		skills for managing projects, project teams, and stakeholders.			
32.	**Biomedical Instrumentation**	After completion of this course, students will be able to: • Describe the principle of interfacing of Electrode-electrolyte and different types of electrodes which are used in biomedical field. • Explain different types of recorders and photometers. • Describe the method of measurement of BP and blood flow.	—	—	**No Change in course contents.**
			Text Book: 1. Leslie Cromwell: "Biomedical Instrumentation and measurement". Prentice hall of India, New Delhi, 1997. **References :** 2. John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 1998. 3. KhandpurR.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, 1997. 4. Joseph J.carr and John M. Brown, **"Introduction to Biomedical equipment Technology"** John Wiley and sons. New York, 1970.	**Recommended Books:** 1. Cromwell L. (2007). *Biomedical Instrumentation and Measurement.* New Delhi: PHI Publication 2. Webster J.G.(1998). *Medical Instrumentation Application and Design*. New York: John Wiley and Sons 3. KhandpurR.S. (1997). *Handbook of Biomedical Instrumentation.* New Delhi: Tata McGraw-Hill Publication 4. Carr J. J. & Brown J. M. (1997). *Introduction to Biomedical Equipment Technology.* New York*:* John Wiley and sons	
33.	**Optical Network**	After completion of this course, students will be able to: • Describe the important components such as multiplexer, filters. • Explain the multiplexing technique • Explain the signalling and routing of WDM network elements • Describe the protection technique in SONET/SDH and IP network	—	—	**No Change in course contents.**
			Text Books: 1. Ramaswami, Rajiv &Sivarajan, Kumar N.: **Optical Networks a Practical perspective:** Morgan Kaufmann Publishers / 2nd Ed. 2. Black, Uyless: **Optical Networks Third Generation Transport Systems:** Pearson Educations. **Reference Books:** 1. Tanenbaum. Andrew S.: **Computer Networks:** Prentice Hall (India) 2. Murthy, C. Siva Ram &Gurusamy, Mohan: **WDM Optical Networks Concepts, Design & Algorithms:** Prentice Hall (India)	**Recommended Books:** 1. Ramaswami, Rajiv.,&Sivarajan, Kumar. N.(2009). *Optical Networks: A Practical Perspective*. San Francisco, California: Morgan Kaufmann Publisher. **2.** Uyless, Black. (2009). *Optical Networks Third Generation Transport Systems***:** New Delhi: Pearson Publication. **3.** Tanenbaum, Andrew. S. (2010). *Computer Networks***.** New Delhi: Pearson Publication. **4.** Murthy, C. Siva Ram.,&Gurusamy Mohan. (2001). WDM, Optical Networks Concepts, Design & Algorithms**.** New Delhi: Pearson Publication. **Suggested e-resources:** **1. Introduction to Optical Networks** by YatindraNath Singh, Department of Electrical Engineering, Indian Institute of	

				Technology, Kanpur. http://home.iitk.ac.in/~ynsingh/seminars/OptNets.pdf 2. **Optical networks and Switching Systems** by Prof. Yatindra N Singh, Department of Electrical Engineering Indian Institute of Technology, Kanpur. https://nptel.ac.in/syllabus/117104021	
34.	**Satellite Communication**	After completion of this course, students will be able to: • Identify the fundamentals of orbital mechanics, the characteristics of common orbits used by communications and other satellites. • Understand the systems required by a communications satellite to function and the trade-offs and limitations encountered in the design of a communications satellite system. • Understand the radio propagation channel for Earth station to satellite and satellite to satellite communications links, and the basics of designing antenna systems to accommodate the needs of a particular satellite system. • Understand how analog and digital technologies are used for satellite communications networks and the topologies and	—	—	**No Change in course contents.**
			Text Books: 1. Pratt, Bostian, Allnutt: **Satellite Communications:** John Wiley & Sons. 2. Dennis Roddy: **Satellite Communications:** McGraw-Hill 3. Tri T. Ha: **Digital Satellite Communications:** McGraw-Hill.	**Recommended Books:** 1. Bostian, Charles.,Pratt, Timothy., & Allnutt, Jeremy. (2006). *Satellite Communications***.** New Delhi: John Wiley & Sons. 2. Maral G., Bousquet M., Sun Z. (2010) *Satellite Communications Systems : Systems, techniques and technology*, 5th edition, , John Willy and sons. 3. Roddy, Dennis. (2017). *Satellite Communications***.** New Delhi:McGraw-Hill Publication 4. Ha, Tri. T. (1990). *Digital Satellite Communications.* New Delhi: McGraw-Hill Publication **Suggested e-resources:** 1. **Satellite Communication Systems** by Prof.Kalyan Kumar Bandyopadhyay Department of Electronics and Electrical Communication Engineering Indian Institute of Technology, Kharagpur. http://textofvideo.nptel.ac.in/117105131/lec1.pdf 2. **Satellite Link Design** by Dr.Marwah Ahmed. https://net425site.files.wordpress.com/2017/02/net-425-d-feb-2016-lec-5.pdf	**Added**

		applications of those networks, as well as the comparison to alternative communications systems.			
35.	**Basics of Nanoelectronics**	After completion of this course, students will be able to: • Explain the fundamental science and quantum mechanics behind nanoelectronics. • Explain the basic concepts behind the operation of nano scale MOSFET • describe the various techniques and approaches for the fabrication of nano-scale devices	—	—	**No Change in course contents.**
			Text books: 1. G. W. Hanson: **Fundamentals of Nanoelectronics**, Pearson Education. 2. K. K. Chattopadhyay and A. N. Banerjee: **Introduction to Nanoscience and Nanotechnology**, PHI Learning. **References:** 1. Vlaadiniz U. Mitin: **Introduction to Nanoelectronics**, Cambridge University Press. 2. M. Dragman and D. Dragman: **Nanoelectronics- Principles and devices**, Artech House. 3. Karl Goser: **Nanoelectronics and Nanosystems**, Springer. 4. Daniel Minoli: **Nanotechnology application to telecommunication and networking**, Wiley Interscience. 5. John H. Davis: **Physics of low dimension semiconductor**, Cambridge Press. 6. Carl C. Cosh: **Nanostructure materials processing property and applications**, Noyes Publications	**Recommended Books:** **1.** Hanson, G. W. (2008). *Fundamentals of Nanoelectronics*. New Delhi: Pearson Publication. **2.** Chattopadhyay, K. K., & Banerjee, A. N. (2009). *Introduction to Nanoscience and Nanotechnology*. New Delhi: PHI Publication. **3.** Mitin, Vlaadiniz.U. (2009). *Introduction to Nanoelectronics*. New Delhi: Cambridge University Press. **4.** Dragman,M., &Dragman,D. (2008). *Nanoelectronics- Principles and Devices (2/e*): Artech House Publishers **5.** Goser, Karl. (2004). *Nanoelectronics and Nanosystems*. Berlin: Springer Publication **6.** Minoli, Daniel. (2005). *Nanotechnology Application toTelecommunication and Networking*. Hoboken, New Jersey: Wiley Publication. **7.** Davis ,John. H. (1997). *Physics of Low Dimension Semiconductor*. New Delhi: Cambridge University Press. **8.** Cosh, Carl.C. (1998). Nanostructure Materials Processing Property and Applications. Norwich, New York: Noyes Publications	
36.	**Mobile Communication**	After completion of this course, students will be able to: • To understand the various generations of mobile communications and	—	—	**No Change in course contents.**
			Text Book: 1. Rappaport Theodre S: **Wireless Communication:** Pearson Education, second	**Recommended Books:** 1. Rappaport, Theodre. S. (2014) *Wireless Communication***.** New Delhi: Pearson Publication.	

		basics of wireless communication • To understand the concept of cellular communication • Can test mobile communication equipment for the technical functionality • Knowledge of GSM mobile communication standard, its architecture, logical channels, advantages and limitations	edition. 2. Pandya Raj: **Mobile and Personal Communication System and Services:** Prentice Hall of India. **Additional Reading:** 1. David J. Goddman: **Wireless Personal Communication System:**Addision Wesley publication. 2. Joachim Tesal: **GSM cellular Radio:** John Wiley publication.	2. Pandya, Raj. (1999). *Mobile and Personal Communication System and Services***:** New Delhi: PHI Publication. 3. Goddman, David.J. (1997). *Wireless Personal Communication System***:**Addition Wesley Publication. 4. Tesal, Joachim. (1997). *GSM cellular Radio***:** New Delhi: John Wiley Publication **Suggested E-Resources:** 1. **Wireless Communications** by Prof.Dr.Ranjan Bose, Department of Electrical Engineering, IIT Delhi. https://nptel.ac.in/courses/117102062/	
37.	**Radar Navigation**	After completion of this course, students will be able to: • Understand the basic concept of Radar and applications of various types. • Understand the different Radar Performance factors. • Explain the operation of CW& FM Radar. • Understand the Satellite navigation system.	—	—	**No Change in course contents.**
			Text Books: 1. Mark A Richards: **Fundamentals Of Radar Signal Processing**: TMH. 2. N. S. Nagraja: **Elements of Electronics Navigation**: TMH. 3. Peebles Jr. P. Z: Radar Principles: Wiley, NY.	**Recommended Books:** 1. Richards, Mark. A (2014). *Fundamentals of Radar Signal Processing*. New Delhi:TMH Publication. 2. Nagraja, N. S. (2009). *Elements of Electronics Navigation*: New Delhi:TMH Publication. 3. Peebles Jr. P. Z. (1998). *Radar Principles.* New Delhi: Wiley Publication. **Suggested E-Resources:** **1. Introduction to Radar Systems** by Dr. Robert O'Donnell, Massachusetts Institute of Technology. https://ocw.mit.edu/resources/res-ll-001-introduction-to-radar-systems-spring-2007	
38.	**Analytical Instrumentation**	After completion of this course, students will be able to: • Explain majorly pH conductivity & dissolved component	—	—	**No Change in course contents.**
			Text Books: 1. Jones E.B: **Instrumentation technology**. 2. Jain R.K: **Mechanical & Industrial**	**Recommended Books:** 1. Willard., Merritt.Dean,& Settle. (2004). *Instrumental Methods of Analysis*. New	

		analyzer, dissolved oxygen analyzer, sodium analyzer, silica analyzer and moisture measurement. • Evaluate the performance of Spectro-photometers, FTIR Spectrometers and their applications. • Describe modern trends in NMR Spectrometers, X-ray Spectrometry, and Mass Spectrophotometers with their applications.	**Measurements:** Khanna Publications. 3. R.S. Khandpur, Handbook of Analytical Instruments, TMH, New Delhi **Reference Books:** 1. D. A. Skoog, Principles of Instrumental Analysis, Saunders College Publishing, Philadelphia 2. H. H. Willard, L.L. Merrit, J. A, Dean and F. A. Settle, Instrumental methods of Analysis, CBS Publishers, Delhi 3. D. Patranabis, Principles of Industrial Instrumentation, TMH, New Delhi	Delhi: CBS Publishers & Distributors. 2. Ewing, Galen.W. (1985). *Instrumental Methods of Chemical Analysis*. New Delhi: McGraw-Hill Publication. 3. Liptak, B.G. (1995). *Process Measurement and Analysis*. Philadelphia: Chilton Book Company. 4. Settle,Frank.A. (1997). *Handbook of Instrumental Techniques for Analytical Chemistry*. New Delhi: PHI Publication. 5. Braun, Robert.D. (2012). *Introduction to Instrumental Analysis*. Hyderabad, Karnataka:BSP Books Pvt.Ltd. 6. Skoog. Holler.,&Crouch. (2017). Principles *of Instrumental Analysis*. New Delhi: Cengage Learning Publication. **Suggested e-resources:** 1. **Modern Instrumental Methods of Analysis**by Prof. J. R. Mudakavi, Department of Chemical Engineering, Indian Institute of Science, Bangalore. https://nptel.ac.in/courses/103108100/	
39.	**Geoinformatics**	After completion of this course, students will be able to: • Describe spatial database, Co-ordinate and projection system • Analyse vector and raster based analysis in Geographical Information Sciences • Describe global cover based global position systems i.e. GPS, GLONASS • Describes applications of remote sensing and GIS in natural resources management	—	—	**No Change in course contents.**
			Text Books : 1. Chor Pang Lo and Albert K. W. Yeung. 2006. Concepts and Techniques-of Geographic Information Systems (2nd Edition). Prentice-Hall, Inc., Upper Saddle River, NJ, USA. 2. Heywood, D.I. and Cornelius, S. and Carver, S. 2011. An Introduction to Geographical Information Systems. Pearson, Prentice-Hall, Inc. 3. Joseph, G. 2005. Fundamentals of remote sensing. Universities prc;s (India) Pvt Ltd., Hyderabad. 4. Jensen, John R. 2016. Introductory digital image processing: a remote sensing perspective. Upper Saddle River, N.I.: Prentice Hall. 5. Sabins, Floyd F. 1997. Remote	**Recommended Books:** 1. Chor, Pang. Lo.,&Albert, K. W. Yeung (2006). *Concepts and Techniques-of Geographic Information Systems*. New Delhi: PHI Publication. 2. Heywood, D.I., Cornelius, S. & Carver, S. (2009). *An Introduction to Geographical Information Systems*. New Delhi: Pearson Publication. 3. Joseph, G. (2005). *Fundamentals of remote sensing*. Jaipur, Rajasthan: Universities Press. 4. Jensen, John. R. (2015). *Introductory Digital Image Processing: A Remote Sensing Perspective*. New Delhi: Pearson Publication. 5. Sabins, Floyd F. (2007). *Remote Sensing: Principles and Interpretation*. Long	

			sensing: principles and interpretation. San Francisco: W.H. Freeman	Grove, Illinois: Waveland Press **Suggested e-resources:** 1. **Geoinformatics** by University of Twente. https://www.itc.nl/ilwis/applications-guide/ 2. **Geographical Information System** by Dr A. K. Gosain, Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/105102015/1	
40.	**Audio and Video Systems**	After completion of this course, students will be able to: • Understand the fundamental concepts of television transmitter, receiver systems and the transmission of video signals and importance of television standards. • Understand different colour television systems used worldwide and its compatibility. • Principles of recording and reproduction of disc and video cassette recorders.	—	—	**No Change in course contents.**
			Recommended Books: 1. S.P. Bail & R. Bali: **Audio Video systems:** Khanna Book Publishing Co. Delhi. 2. Ajay Sharma: **Audio and Video Systems:**Dhanpat Rai & Co. 3. R.G. Gupta: **Audio and Video Systems:** Tata Mc-Graw Hill.	**Recommended Books:** 1. Bali, S.P.,&Bali, R. (2014). *Audio Video Systems Principles, Practices, and Troubleshooting***.** New Delhi: Khanna Book Publishing Co. 2. Sharma, Ajay. (1998). Audio *and Video Systems***.** New Delhi: Dhanpat Rai & Co. 3. Gupta, R.G. (2010). *Audio and Video Systems: Principles, Maintenance and Troubleshooting***.** New Delhi: Tata Mc-Graw Hill **Suggested e-resources:** **1. Digital Video Signal Processing** by Prof.Sumana Gupta, Department of Electrical Engineering, IIT Kanpur. https://nptel.ac.in/courses/117104020/1 **2. Audio System Engineering** by Prof.Shyamal Kumar Das Mandal, Department of Electronics and Communication Engineering, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105133/22	
41.	**Robotics and Automation**	After completion of this course, students will be able to: • Develop skills of creating industrial and	----	**SECTION A** **BASIC CONCEPTS-** Automation and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and	**Addition of as Elective**

		mobile robot projects • Implement robots like KUKA, PUMA in real industrial world • Create innovative robot designs using mathematical concepts of kinematics • Develop autonomous mobile robots in surveillance, security, home and office services		control system, Dynamic stabilization of Robotics. **POWER SOURCES AND SENSORS-** Hydraulic, Pneumatic and electric drivers – Determination HP of motor and gearing ratio, variable speed arrangements, Path Determination - Machinery Vision – Ranging – Laser – Acoustic, Magnetic Fiber Optic and Tactile Sensor.	
			-----	**SECTION B** **MANIPULATORS-** Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and Pneumatic manipulators. **ACTUATORS AND GRIPPERS-** Pneumatic, Hydraulic Actuators, Stepper Motor Control Circuits, End Effecter, Various types of Grippers, Design consideration. Differential transformation and manipulators, Jacobians – problems .Dynamics: Lagrange – Euler and Newton – Euler formations – Problems.	
			----	**SECTION C** **KINEMATICS-** Forward and Inverse Kinematic Problems, Solutions of Inverse Kinematic problems, Multiple Solution, Jacobian Work Envelop – Hill Climbing Techniques. **PATH PLANNING-** Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion – straight line motion – Robot programming, languages and software packages. **CASE STUDY-** Multiple Robots – Machine Interface – Robots in Manufacturing and Non-Manufacturing applications – Robot Cell Design Selection of a Robot.	
				Recommended Books: 1. Groover, M. P., Weiss, M., Nagel, R. N., & Odrey, N. G. (2017). *Industrial Robotics: Technology, programming, and Applications* (2/e). McGraw-Hill	

				Education Publication 2. Niku, S. (2010). *Introduction to robotics*. John Wiley & Sons. 3. Fu, K. S., Gonzalez, R., & Lee, C. G. (1987). *Robotics: Control Sensing. Vis*. Tata McGraw-Hill Education. 4. Mittal, R. K., & Nagrath, I. J. (2003). *Robotics and control*. Tata McGraw-Hill. 5. Craig, J. J. (2009). *Introduction to robotics: mechanics and control, 3/E*. Pearson Education India. 6. Spong, M. W., & Vidyasagar, M. (2008). *Robot dynamics and control*. John Wiley & Sons. 7. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2010). *Robotics: modelling, planning and control*. Springer Science & Business Media.	
42.	**Power Electronics**	After completion of this course, students will be able to: • To explain various power semiconductor devices like Thyristor, GTO, MOSFET and IGBT • Analyze the various rectifiers used in power circuits and DC to DC Converters • Explain the inverter operation and how harmonics are reduced and explain the basic working principle of cyclo-converters	**Section A** Need of power electronics, Introduction to power electronics devices (static and dynamic characteristics) power diodes, power transistor, power MOSFETS, IGBT, MCT, GTOs, Triac. Thyristor SCR: Operational characteristics, Turn ON methods, switching characteristics, thyristor protection, over voltage protection, over current protection, gate protection, snubber circuit Firing circuits for Thyristors, heating, series and parallel combination of Thyristors.	--	**Shifted from 6th semester to list of electives.** **No change in course contents.**
			Section B Commutation Techniques: Load commutation, resonant- pulse commutation, complementary commutation, impulse commutation, line commutation, Phase controlled rectifier: Principal of phase control, single and three phase converters. Effect of source impedance on the performance of converters, dual converter (ideal and practical) DC choppers: Principle, control strategies, step-up and step-down choppers.	--	
			Section C Inverters: Single-phase voltage source	--	

			inverters 180 and 120 mode operation; Fourier analysis of single-phase inverter output voltage. Pulse width modulated inverters, Reduction of harmonics in the inverter output, single-phase current source inverters with ideal switch. Cyclo-converters: Step-up and step-down cyclo-converter, Single phase to single-phase cyclo-converters three-phase half wave cyclo-converters.		
			Text Books: 1. Rashid Muhammad H.: **Power Electronics Circuits, Devices And Applications:** PHI publication, 14th reprint Edition. 2. Bimbhra P.S.: **Power Electronics:** Khanna Publication, 3rd Edition. **Reference:** 1. Rama Moorthy: **An Introduction To Thyristors And Their Application:** 2nd Edition, ISBN-81-85336-67-9.	**Recommended Books:** **1.** Rashid, Mohammad. H. (2017) .*Power Electronics Circuits, Devices And Applications*: New Delhi: PHI Publication. **2.** Bimbhra, P.S. (2012). *Power Electronics***:** New Delhi: Khanna Publication. **3.** Moorthy, Rama, (1991). *An Introduction ToThyristors and Their Application***:** New Delhi: Affiliated East-West Press. **Suggested E-Resources:** 1. **Power Electronics** by Prof.B.G. Fernandes, Department of Electrical Engineering, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101038/ **2. Power Electronics** by Prof. D. Prasad, Dr. D. Kastha, Prof.SabyasachiSengupta, Prof. N. K. De, Dept of Electrical Engineering, IIT Kharagpur. https://nptel.ac.in/courses/108105066/	
43.	**Digital Signal Processing**	After completion of this course, students will be able to: • Students will be familiar with the most important methods in DSP. • Students will be familiar with design and functioning of digital filter design • Student will be able	**Section A** Introduction of Signals, Systems and Signal Processing, Classification of Signals and Systems, Advantages of digital over analog Signal processing, Signal Models - Continuous Time versus Discrete time signals, Periodic and aperiodic Signals, Phasor Signals and Spectra, Energy and Power Signals, System Modeling Concepts, The superposition integral for Fixed and Linear Systems, Impulse Response of a Fixed and Linear System - Fourier Series -	--	**Shifted from 6th semester to list of electives.** **No change in course contents. No Change**

		to transform-domain processing.	Trigonometric Series- Exponential Fourier Series-Symmetry Properties of the Fourier Coefficients. Fourier Integral, Energy Spectral Density, Fourier Transforms in the Limit, Fourier Transform Theorems and Pairs, System Analysis with Fourier Transform, Lap lace Transform Theorems, Network Analysis using the Lap lace Transform.		
			Section B Discrete Time Signals and Systems - Review of Sampled Data Systems, Time Domain Representations of Discrete Time Signals, Frequency Domain Representation of Discrete Time Signals, Discrete Time Signals obtained by sampling, Discrete Fourier Transform. Z-Transform - Definition and Examples, Inverse Z-Transform, Properties of the Z-Transform, Introduction to Realization of Digital Systems - Block Diagrams and Signal Flow Graphs. Introduction to Realization of an IIR and FIR systems, Discrete Fourier Transforms (DFT) and Fast Fourier Transform (FFT).	--	
			Section C Design of Digital Filters: Introduction to Filters, A comparison of IIR and FIR Digital Filters. Design of IIR Digital Filters –Impulse Invariant Transformation, Bilinear Transformation, Design of Digital Butter worth and Chebyshev Filters. Design of FIR Digital Filters - Windowing and Rectangular Window, Filter Designs using Windows, Frequency Sampling Technique. DSP tools and DSP techniques in various applications.	--	
			Text Books: 1. Johnson Johnny R.: **Introduction to Signal Processin:** Prentice-Hall of India, 1998. 2. Oppenheim V. Alan: **Signal &**	**Recommended Books:** **1.** Johnson, Johnny. R. (1998). **Introduction to Signal Processing**. New Delhi: phi Publication. **2.** Oppenheim, V. Alan. (1995). **Signal &**	

			Systems: Prentice-Hall of India, 1995. 3. ProakisG.John: **Digital Signal Processing:** Prentice-Hall of India, 3rd edition, 2002.	**Systems**. New Delhi: PHI Publication. **3.** Proakis, G.John. (2002). **Digital Signal Processing.** New Delhi: PHI Publication. **Suggested E-resource**: 1. Digital Signal Processing by Prof: S. C. Dutta Roy, Department of Electrical Engineering Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/117102060/	
44.	**Mechatronics**	After successful completion of the course, student will be able to: • Develop skills to monitor and control real world industrial systems • Implement projects for industrial and home automations • Analyze and create own innovative filters and signal conditioning applications • Perform computer based controlling of industries using PLC, SCADA and HMI		**SECTION A** **Mechatronics and its scope**: Basic Structure and Evolution **Introduction of Transducer & Sensor:** Displacement, Pressure, Flow, Level and Temperature Measurements. Signal conditioning: amplification, filtering **PC based Control:** Smart Sensor, Data Acquisition System, PLC, SCADA, DCS and HMI System.	**Addition of new elective.**
				SECTION B **Pneumatic and Hydraulic actuation systems:** Directional control valves, Pressure control valves and Process control valves and cylinders. **Mechanical actuation system-** Kinematic chains, cams, gear-trains, Ratchet & Pawl, dampers, Bearings. **Electrical actuation system:** Mechanical switches- solenoid operated solid state switches, DC, AC & stepper motors. **Electrical Drives:** Conventional and Modern electrical drives, Classifications and Applications Closed loop Controllers: Performance Specifications, Delayed First and Second order system, PID Controller, ZN Tuning.	
				SECTION C **Case Studies of Mechatronics Systems:** Industrial Robot, Automobile Engine Control, Vehicle Suspension Control, MEMS, CNC Machine, Gyro system, 3-D Printer.	
				Recommended Books:	

				1. Isermann**,** Rolf (2005). *Mechatronics Systems*. Springer Publication 2. Bolton, W. (2003). *Mechatronics: electronic control systems in mechanical and electrical engineering*. Pearson Education. 3. Sawhney A.K. (2015). *A Course in Electrical and Electronic Measurements and Instrumentation*. Dhanpat Rai & Co Publication 4. Nakra B.C. & Chaudhry K.K. (2013). *Instrumentation, Measurement and Analysis.* Tata McGraw Hill Publication	
45.	**Professional Ethics**		**---**	The course is intended to provide participants with the ability to analyze ethical situations, such as how they interact and what can be expected from them as correct ethical behaviour. In turn, any professional will benefit from a critical scrutiny of their own ethics by those from other professions. The general principles of professional ethics will be examined, as well as the distinctive problems of the different fields. The participant will also be expected to explain the pertaining issues, such as professional codes of ethics, confidentiality, obligations and Moral Values in Professional Ethics, the limits of predictability and responsibilities of the engineering profession, research misconduct, and work place rights & responsibilities. **Suggested e-resources:** 1. **Professional Ethics** by Rochester Institute of Technology. http://www.openculture.com/professional-ethics-a-free-online-course. 2. **Ethical Practice: Leading Through Professionalism, Social Responsibility, and System Design** by Prof. LeighHafrey, MIT, USA. https://ocw.mit.edu/courses/sloan-school-of-management/15-270-ethical-practice-	**New reading elective added**

				leading-through-professionalism-social-responsibility-and-system-design-spring-2016.	
46.	**IoT Sensors and Devices**		-----	This course is for practical learners who want to explore and interact with the IoT bridge between the cyber- and physical world. Student will learn about the 'things' that get connected in the Internet of Things to sense and interact with the real world environment – from something as simple as a smoke detector to a robotic arm in manufacturing. This course is about the devices that feel and the devices that respond. The course also describe about IoT sensors, actuators and intermediary devices that connect things to the internet, as well as electronics and systems, both of which underpin how the Internet of Things works and what it is designed to do. **Suggested e-resources:** 1. **IoT Sensors and Devices** by Curtin University https://www.edx.org/course/sensors-and-devices-in-the-iot. 2. **Internet of Things: Sensing and Actuation** by University of California San Diego https://www.coursera.org/learn/internet-of-things-sensing-actuation.	**New reading elective added**
47.	**Electromagnetic Compatibility**		-----	This course describe the systems that generate or consume electrical energy can produce electromagnetic noise that may interfere with the operation of the system itself and/or other systems. The course will enable students to understand how the principles of electricity and magnetism can be applied to design electrical and electronic systems that can co-exist harmoniously, that is, to design systems that are electromagnetically compatible with each other. The students will also be expected to explain how electromagnetic disturbances are generated in systems, how they couple to	**New reading elective added**

				other systems, and how systems can be protected. **Suggested e-resource:** 1. **Electromagnetic Compatibility** by Daniel Mansson, KTH Royal Institute of Technology, Sweden https://onlinecourses.nptel.ac.in/noc19_ee17/preview.	
48.	**Electric Vehicles**		-----	Electric vehicles are the future of transportation. Electric mobility has become an essential part of the energy transition, and will imply significant changes for vehicle manufacturers, governments, companies and individuals. This course prepare the students for product development positions in the automotive, communications, solar, wind turbine, and smart grid industries and service positions in the automotive industry. This course will be a first level course on electric vehicle. Students will be able to understand the operation of battery driven electric vehicle. The course will focus on areas that come under the umbrella of electric vehicles, such as vehicle dynamics, Motors, Power Electronics, Batteries, Charging and etc. Students will explore the most important aspects of this new market, including state-of-the-art technology of electric vehicles and charging infrastructure **Suggested e-resources:** 1. **Electric Vehicles Part 1** by IIT Delhi. https://onlinecourses.nptel.ac.in/noc19_ee18/preview. 2. **Electric Cars: Introduction** by Delft University of Technology (TU Delft). https://www.edx.org/course/electric-cars-introduction-0.	
49.	**Electronic Packaging**		-----	This course is designed to provide a basic knowledge of the technologies and processes required for the packaging of electronic products. The focus of the course will be on the mechanical, and materials aspects which are often neglected in the design phase with	**New reading elective added**

				potentially catastrophic consequences. Students will be expected to explore the underlying scientific and technological knowledge-based needed to become proficient builders and users of electronic systems. The students will also be able to explain the fundamental principles for packaging active and passive electronic devices; design of components, circuit boards, connectors, and assemblies; electromagnetic interference and its impact on packaging, thermal and mechanical design; and reliability assessment methods.	
				Suggested e-resource: 1. **Electronics Packaging and Manufacturing** by IIT Kharagpur https://onlinecourses.nptel.ac.in/noc18_me54.	
50.	**Multimedia Compression and Communication**		**-----**	The purpose of this course is to understand the multimedia communication and compression. In this course students will be expected to explore various multimedia components and their characteristics, such as hardware, animation and graphics and able to explain the various audio and video compression techniques and apply these techniques in multimedia communication. The student will also be able to develop the understanding of network architecture, protocols, resource management, multimedia operating systems, scheduling and policing mechanisms.	**New reading elective added**
				Suggested e-resource: **1. Multimedia Processing** by IIT Kharagpur. https://nptel.ac.in/syllabus/117105083/.	
51.	**Telecommunication switching systems and networks**		**-----**	The course is intended to develop the good understanding of the fundamentals and application of telecommunication networks i.e. PSTN, PDN and ISDN, modern digital telecommunication switching and networks. The participants will be expected to explain the recent terminology, like switching	**New reading elective added**

				systems, traffic management, time division switching systems, data communication Networks, routing, ISDN, voice data integration and importance of telephone traffic analysis and telephone networks.	
				Suggested e-resources: 1. **Computer Networks** by Department of CSE, IIT Kharagpur https://nptel.ac.in/courses/Webcoursecontents/IIT%20Kharagpur/Communication%20network/New_index1.html. **2. Data Communication** by IIT Kharagpur. https://nptel.ac.in/courses/106105082/19.	

Annexure III

Name of Programme: Master of Science (Electronics)

Programme Educational Objectives: The M.Sc. (Electronics) programme aims for the holistic development of students through the unique and innovative fivefold educational ideology of Banasthali Vidyapith. Electronics now become the integral part of our lives. As the world continues to rely on Electronics technology, there is a great requirement for the technically skilled personnel who are able to design, create, and maintain the many products and systems that support electronics technology. Electronics professionals develop innovative technology solutions in a wide range of areas from handheld communications to solar panels; from cardiac pacemakers to autonomous robots; from wireless networks to bio-engineered sensors that detect dangerous pathogens; and intelligent surveillance systems that perform face and motion recognition.

The program aims to deepen the knowledge and skills of the students on the basic concepts and theories that will equip them in their professional work involving analysis, systems implementation, operation, production, and maintenance of the various applications in the field of Electronics. The curriculum is designed in a way that it will equip students with a solid grasp of mathematical, scientific, and engineering concepts, through classroom education and laboratory exercises. Graduates of the program are expected to develop and use professional skills that facilitate their continued carrier growth well beyond their graduation.

The main objectives of the program are:

- To provide students solid foundation in mathematics and electronics fundamentals required to solve subject related problems and also to pursue advanced studies. This serves them lifelong in their professional domain as well as higher education.
- To prepare professionals to work in inter-disciplinary environment, either independently or in a team, and demonstrate leadership qualities.
- Practice the ethics of their profession, consistent with a sense of social responsibility and develop their problem–solving skills and aptitude for innovations as they work individually and in multi-disciplinary teams.
- Inculcate a lifelong learning culture.
- To formulate problems and projects and to plan a process for solution.
- Communicate effectively and manage resources skilfully as members and leaders of the profession.

Programme Outcomes:

PO1. **Knowledge**: Apply the knowledge of mathematics, science and electronics fundamentals to the solution of related complex problems.

PO2. **Problem analysis:** Interpret, compare and analyze following rules of scientific methodology to arrive at a defensible conclusion of a problem.

PO3. **Design/development of solutions:** Develop solutions for complex electronics problems and design system components/processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems:** Use scientific knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage:** Apply appropriate techniques, resources, and modern electronics tools including MATLAB, LabView, Proteus, VHDL, Arduino and related hardware to complex electronics activities with an understanding of the limitations.

PO6. **The electronics professional and society:** Apply reasoning gained by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional electronics practice.

PO7. **Environment and sustainability:** Understand the impact of the professional electronics solutions in societal and environmental contexts, and demonstrate the knowledge for sustainable development.

PO8. **Ethics:** Apply ethical principles and commit to professional ethics responsibilities and norms of the professional practice.

PO9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary surroundings.

PO10. Communication Skill: Communicate effectively on complex electronics activities with the electronics professional community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the professional and management principles and apply as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Scheme:

M.Sc. (Electronics) I Sem (December 2019)

1. **Highlighted with gray shade indicates the changed subject/course/credit/modification in syllabus/ new course added.**
2. **Text in white color with black background indicates swapping of course.**

Existing Scheme						**Proposed Scheme**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
~~CS 416~~	~~Computer Programming~~	4	0	0	4	CS 415	Computer Programming	4	0	0	4
~~CS 416L~~	~~Computer Programming Lab~~	0	0	8	4	CS 415L	Computer Programming Lab	0	0	8	4
ELE 301	Analog Integrated Circuits	4	0	0	4		Analog Electronics	4	0	0	4
ELE 301L	Analog Integrated Circuits Lab	0	0	2	1		Analog Electronics Lab	0	0	4	2
~~ELE 404~~	~~Electronics Devices~~	4	0	0	4	ELE 406	Principles of Digital Electronics	4	0	0	4
~~ELE 405~~	~~Network Theory~~	4	0	0	4	ELE 406L	Principles of Digital Electronics Lab	0	0	4	2
~~ELE 405L~~	~~Network Theory Lab~~	0	0	2	1	ECE 201	Signals, systems and Networks	4	0	0	4
ELE 406	Principles of Digital Electronics	4	0	0	4	ELE 205	Semiconductor Devices and Circuits	4	0	0	4
ELE 406L	Principles of Digital Electronics Lab	0	0	4	2						
Semester Wise Total		20	0	16	28	**Semester Wise Total**		20	0	16	28

M.Sc.(Electronics) II Sem (April/May 2020)

Existing Scheme						**Proposed Scheme**					
Course Code	**Course Name**	**L**	**T**	**P**	**C ***	**Course Code**	**Course Name**	**L**	**T**	**P**	**C ***
~~ECE 402~~	~~Fiber Optics and Communication~~	4	0	0	4		Microwave Engineering	4	0	0	4
~~ECE 402L~~	~~Fiber Optics and Communication Lab~~	0	0	2	1		Microwave Engineering Lab	0	0	2	1
EIE 201	Electronics Measurement and Instrumentation	3	1	0	4	EIE 202	Electrical and Electronics Measurements	3	1	0	4
EIE 201L	Electronics Measurement and Instrumentation Lab	0	0	2	1	EIE 202L	Electrical and Electronics Measurements Lab	0	0	4	2
EIE 302	Control Systems	3	1	0	4	EIE 302	Control Systems	4	0	0	4
EIE 302L	Control Systems Lab	0	0	2	1	EIE 302L	Control Systems Lab	0	0	4	2
~~ELE 304~~	~~Digital Signal Processing~~	4	0	0	4	MGMT 209	Entrepreneurship	3	0	0	3
~~ELE 304L~~	~~Digital Signal Processing Lab~~	0	0	2	1	TSKL 403	Communication Skills	2	0	0	2
TSKL 403	Communication Skills	2	0	0	2	ELE 508S	Seminar	0	0	2	1
VLSI 401	VLSI Design	4	0	0	4		Discipline Elective	4	0	0	4
VLSI 401L	VLSI Design Lab	0	0	4	2						
Semester Wise Total		20	2	12	28	**Semester Wise Total**		20	1	12	27

M.Sc. (Electronics) III Sem (December 2020)

Existing Scheme						**Proposed Scheme**					
Course Code	**Course Name**	**L**	**T**	**P**	**C ***	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 307	Microwave Electronics	4	0	0	4	VLSI 401	VLSI Design	4	0	0	4
ELE 307L	Microwave Electronics Lab	0	0	2	1	VLSI 401L	VLSI Design Lab	0	0	2	1
ELE 306	Microprocessors and Microcontrollers	3	1	0	4	CS 209	Data Structures	4	0	0	4
ELE 306L	Microprocessors and Microcontrollers Lab	0	0	2	1	CS 209L	Data Structures Lab	0	0	4	2
ECE 301	Analog Communication	4	0	0	4	ECE 301	Analog Communication	4	0	0	4
ECE 301L	Analog Communication Lab	0	0	2	1	ECE 301L	Analog Communication Lab	0	0	2	1
CS 209	Data Structures	4	0	0	4	ELE 306	Microprocessors and Microcontrollers	4	0	0	4
CS 209L	Data Structures Lab	0	0	4	2	ELE 306L	Microprocessors and Microcontrollers Lab	0	0	4	2
ECE 303	~~Communication Networks~~	4	0	0	4		Open Elective	4	0	0	4
ELE 308P	Project			8	4		Project	0	0	4	2
ELE 508S	Seminar			2	1						
Semester Wise Total		19	1	20	30	**Semester Wise Total**		20	0	16	28

M.Sc.(Electronics) IV Sem (April/ May 2021)

Existing Scheme						**Proposed Scheme**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Reading Elective	0	0	4	2	ELE 507P	UIL Project	0	0	48	24
ELE 507P	Project	0	0	40	20		Reading Elective	0	0	0	2
Semester Wise Total				44	22	**Semester Wise Total**				48	26

Reading Electives:

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
~~**IT 403R**~~	~~Enterprise Resource planning~~	**0**	**0**	**4**	**2**		Professional Ethics	0	0	0	2
~~**CS 509R**~~	~~Client-Server Computing and Applications~~	**0**	**0**	**4**	**2**		Telecommunication switching systems and networks	0	0	0	2
~~**IT 402R**~~	~~Electronic commerce~~	**0**	**0**	**4**	**2**		Multimedia Compression and Communication	0	0	0	2
~~**CS 427R**~~	~~Parallel Computing~~	**4**	**0**	**0**	**4**		Electronic Packaging	0	0	0	2
							Electric Vehicles	**0**	**0**	**0**	**2**
							Electromagnetic Compatibility	**0**	**0**	**0**	**2**
							IoT Sensors and Devices	**0**	**0**	**0**	**2**

Discipline Electives					
Course Code	**Discipline Electives**	**Course Code**	**Discipline Electives**	**Course Code**	**Discipline Electives**
ELE 403	Basics of Nanoelectronics		Biomedical Instrumentation	ECE 404	Optical Network
	Mechatronics	ECE 402	Fiber Optics and Communication	ECE 406	Satellite Communication
ELE 402	Audio and Video Systems		Analytical Instrumentation	ECE 403	Mobile Communication
	Geoinformatics	ELE 304	Digital Signal Processing	ECE 405	Radar Navigation
	Robotics and Automation	ECE 303	Communication Networks		
	Antenna Analysis	EEE 304	Power Electronics		

Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters II, & III with prior permission of respective heads, time table permitting.

M.Sc. Electronics

Ist Year

Semester-I

Course Code	Course Name	L	T	P	C
CS 415	Computer Programming	4	0	0	4
CS 415L	Computer Programming Lab	0	0	8	4
	Analog Electronics	4	0	0	4
	Analog Electronics Lab	0	0	4	2
ELE 406	Principles of Digital Electronics	4	0	0	4
ELE 406L	Principles of Digital Electronics Lab	0	0	4	2
ECE 201	Signals, systems and Networks	4	0	0	4
ELE 205	Semiconductor Devices and Circuits	4	0	0	4
	Semester Wise Total	20	0	16	28

Semester-II

Course Code	Course Name	L	T	P	C
	Microwave Engineering	4	0	0	4
	Microwave Engineering Lab	0	0	2	1
EIE 202	Electrical and Electronics Measurements	3	1	0	4
EIE 202L	Electrical and Electronics Measurements Lab	0	0	4	2
EIE 302	Control Systems	4	0	0	4
EIE 302L	Control Systems Lab	0	0	4	2
MGMT 209	Entrepreneurship	3	0	0	3
TSKL 403	Communication Skills	2	0	0	2
ELE 508S	Seminar	0	0	2	1
	Discipline Elective	4	0	0	4
	Semester Wise Total	20	1	12	27

IInd Year

Semester-III

Course Code	Course Name	L	T	P	C
VLSI 401	VLSI Design	4	0	0	4
VLSI 401L	VLSI Design Lab	0	0	2	1
CS 209	Data Structures	4	0	0	4
CS 209L	Data Structures Lab	0	0	4	2
ECE 301	Analog Communication	4	0	0	4
ECE 301L	Analog Communication Lab	0	0	2	1
ELE 306	Microprocessors and Microcontrollers	4	0	0	4
ELE 306L	Microprocessors and Microcontrollers Lab	0	0	4	2
	Open Elective	4	0	0	4
	Project	0	0	4	2
	Semester Wise Total	20	0	16	28

Semester-IV

Course Code	Course Name	L	T	P	C
ELE 507P	UIL Project	0	0	48	24
	Reading Elective	0	0	0	2
	Semester Wise Total	0	0	48	26

Discipline Electives		
Basics of Nanoelectronics	Biomedical Instrumentation	Optical Network
Mechatronics	Fiber Optics and Communication	Satellite Communication
Audio and Video Systems	Analytical Instrumentation	Mobile Communication
Geoinformatics	Digital Signal Processing	Radar Navigation
Robotics and Automation	Communication Networks	
Antenna Analysis	Power Electronics	

Reading Electives		
Professional Ethics	Telecommunication switching systems and networks	Electric Vehicles
Electromagnetic Compatibility	Multimedia Compression and Communication	
IoT Sensors and Devices	Electronic Packaging	

Student can opt for at most 2 additional Open (Generic) audit/ credit Elective from other disciplines opting at most 1 per semester in Semesters II, & III with prior permission of respective heads, time table permitting.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
1.	~~**CS 416, Computer Programming**~~	----	----	CS 415, Computer Programming	**Please refer from Department of Computer Science**
2	**Analog Integrated Circuits**	After the completion of course student will be able to: • Explain the operation and properties of Op-amp. • Explain the design of differential amplifiers, active filters, oscillators, and other linear and non-linear circuits using linear integrated circuits. • Design and analysis of single stage, multistage amplifiers and high frequency amplifiers.	~~**Analog Integrated Circuits**~~ **Section A** ~~**Feedback Amplifiers:** classifications of amplifiers, general feedback structure, properties of negative feedback, feedback topologies, Transfer gain with feedback, General Characteristics of negative feedback amplifiers, input resistance, output resistance. Method of analysis, voltage series and current series feedback, current shunt and voltage shunt feedback.~~ ~~**Power amplifiers:** classification, operation, analysis and design of Class A, Class B, Class-AB, Class C, power dissipation and efficiency calculations, amplifier distortion.~~	**Analog Electronics** **Section A** Operational Amplifier and its applications: BJT differential amplifier: DC and AC analysis, Transfer characteristics, Differential and Common mode gain, Ideal Op-amp, inverting and non-inverting amplifier, offset voltage, offset current, bias current, frequency response, slew rate, CMRR, summing amplifier, differential and instrumentation amplifier, design of integrator and differentiator, logarithmic and anti-logarithmic amplifiers, Active filters.	Added Shifted ~~Deleted~~
			Section B **High Frequency Amplifiers :** Hybrid-pi CE transistor model, Hybrid-pi Conductance, Hybrid-pi Capacitances, CE short circuit current gain, current gain with resistive load, single stage CE transistor amplifier response, gain-bandwidth product, **Multistage Amplifiers :** frequency response, Effect of Cascading on bandwidth, RC Coupled amplifier, Low frequency response of an RC coupled stage, Effect of emitter bypass capacitor, High frequency response of two cascaded CE transistor stages, Multistage CE amplifier cascaded at high frequencies.	**Section B** Op-amp RC oscillator circuits: Wien bridge, Phase shift; square wave & triangular wave generator, voltage controlled oscillator, Phase locked loops: performance factors, Integrated circuit PLL (565) and its applications, Precision rectifier, comparator, Schmitt trigger and 555 IC Timer, Voltage Regulators: Voltage regulator basics, OP-AMP series voltage regulators, adjustable voltage regulators, short circuit protection and fold back current limiting circuits, IC voltage regulators , switching regulators.	Added Shifted ~~Deleted~~
			Section C **Operational amplifier & its Applications:** BJT Differential Amplifier: DC and AC	**Section C** High frequency amplifiers: Hybrid –pi CE transistor model, Hybrid –pi conductance,	Added Shifted ~~Deleted~~

			analysis, transfer characteristics, differential and common modes gain. ideal op-amp, inverting and non-inverting amplifier, offset voltage, offset current, bias current, slew rate, CMMR, design of Integrator and differentiator, summing amplifiers, differential and instrumentation amplifiers, Active filters, OP-AMP RC Oscillator circuits : Wien-Bridge, Phase-Shift, Precision rectifier, comparator, Schmitt trigger, 555 IC timer.	Hybrid –pi capacitances, CE short circuit current gain, Current gain with resistive load, Single stage CE transistor amplifier response, Gain bandwidth product. Multistage Amplifier: Frequency response, Effect of cascading on bandwidth, RC coupled amplifier; Low frequency response of an RC coupled stage, Effect of emitter bypass capacitor.	
			Text Books: 1. Millman and Halkias : Integrated electronics, TMH, 1991. 2. ~~Boylestad, Nashelshy, **Electronic Devices and Circuit Theory,** Pearson publication, Tenth Edition, 2009.~~ 3. Gayakwad Ramakant A., "OP-AMP & Linear Integrated circuits", New Delhi (Prentice Hall) fourth Edition 2010. **Reference Book :** 1. Adel Sedra& Kenneth Smith, **Microelectronic Circuits Theory and applications" FIFTH edition International version:** Oxford University Press, 2009.	**Recommended Books:** 1. Gayakwad, Ramakant A. (2010). *OP-AMP & Linear Integrated Circuits.* New Delhi: Prentice Hall Publication. 2. Bell, David A. (2011) *Operational Amplifiers and Linear ICs*. New Delhi: Oxford University Press. 3. Parikh, Millman & Halkias. (2010) *Integrated Electronics: Analog & Digital Circuits and Systems*. New Delhi: McGraw Hill Education. 4. Sedra, Adel. & Smith, Kenneth. (2009).*Microelectronic Circuits Theory and Applications*. New Delhi: Oxford University Press. **Suggested E-Resources:** **1. Analog Electronic Circuits** by Prof. S. C. Dutta Roy, Indian Institute of Technology Delhi. https://nptel.ac.in/courses/108102095/	~~Deleted~~
3.	**Analog Integrated Circuits Lab**	After completion of this laboratory course, students will be able to: • Design, construct, and analyze the various analog circuits to compare experimental results in the	~~**Analog Integrated Circuits Lab**~~ 1. To design the Astable Multivibrator using 555 2. To design the Monostable Multivibrator using 555 3. To design summer using 741 IC 4. To design Intergrator using 741 IC 5. To design Schmitt Trigger using 741/555	**Analog Electronics Lab** 1. To design the Astable Multivibrator using 555 2. To design the Monostable Multivibrator using 555 3. To design summer using 741 IC 4. To design Intergrator using 741 IC 5. To design Schmitt Trigger using	**Learning Outcomes added.** **No Change in Experiment List.**

		laboratory with theoretical analysis. • Observe the amplitude and frequency responses of common amplification circuits • Construct the desired Electronic design to meet specific requirements.	IC 6. To design Differentiator using 741 IC 7. To design peak detector using 741 IC 8. To design scalar using 741 IC 9. To study active filters : LPF, HPF, BPF. 10. To design Voltage to frequency converter. 11. To study phase locked loop. 12. To study frequency shift keying using PLL 565.	741/555 IC 6. To design Differentiator using 741 IC 7. To design peak detector using 741 IC 8. To design scalar using 741 IC 9. To study active filters: LPF, HPF, BPF. 10. To design Voltage to frequency converter. 11. To study phase locked loop. 12. 12. To study frequency shift keying using PLL 565.	
4	**ELE 406, Principles of Digital Electronics**	After the completion of course student will be able to: • Describe and minimize various digital systems. • Design steps for combinational and sequential circuits. • Understand basic memory architectures and their functionality.	**---**	**---**	**No change in course contents**
			Text/Reference Books: 1 Digital Principles and Applications by Malvino C.P., Leach D.P.; Tata Mc-Graw Hill, 1985. 2. Digital Computer Fundamentals:Bartee, T.C. 3. ~~Computer System Architecture: Mano, M.M., Prentice Hall, 1988~~ 4. ~~Digital Electronics: K M Bakwad ,Vardhan Publication, 2010~~ 5. Computer Architecture and Organization : Hayes John P., Mc-Graw Hill 1988 (International Edition) 6. Introduction to Computer Architecture Stone s., Galgotia Publications 1986. 7. Microprocessors, Architecture, Programming & Applications R. Gaonkar, Wiley Eastern - 1987.	**Recommended Books:** 1. Malvino C.P., Leach D.P. & SahaGoutam (2014). *Digital Principles and Applications*. New Delhi: Tata Mc-Graw Hill Publication 2. Bartee T.C. (1979). *Digital Computer Fundamentals.* New York: McGraw-Hill Publication 3. Hayes John P. (1988). *Computer Architecture and Organization.* International edition: McGraw-Hill Publication 4. Stone, Harold S. (1976). *Introduction to Computer Architecture*. Paris: SRA Publication **5.** Gaonkar, R.S. (1987). *Microprocessors Architecture, Programming & Applications with 8085/8080A*, Wiley Eastern Publication	~~Deleted~~
5.	**ELE 406L, Principles of Digital Electronics Lab**	After completion of this laboratory course, students will be able to: • Understand the basic digital circuits and to verify their operation.	**____**	**____**	**Learning Outcomes added** **No change in**

		• Explain the elements of digital system abstractions such as digital representations of information, digital logic, Boolean algebra, state elements and finite state machine (FSMs). • Create a gate-level implementation of a combinational and sequential logic functions described by a truth table using and/or/inv gates, multiplexers.			**experiment list.**
6	**ECE 201, Signals, Systems and Networks**	After the completion of course student will be able to: • Analyze linear time invariant system in time and frequency domain • Apply network theorem to analyze the electrical circuit. • Explain two port parameters.	--	**Section-A** Introduction: Continuous and discrete time signals, Transformation of independent variables, Exponential and sinusoidal signals, Unit impulse and unit step functions, Continuous and discrete time systems, Basic system properties Linear Time-Invariant System: Convolution for continuous and discrete time LTI system, Properties of LTI system, Causal LTI systems described by differential and difference equations, Singularity functions Fourier Series: Fourier series representation of continuous time periodic signals, Convergence of Fourier series, Properties of continuous time Fourier series, Fourier series representation of discrete time periodic signals, Properties of discrete time Fourier series	**Introduced New Course**
			--	**Section-B** Continuous Time Fourier Transform:	

				Representation of a periodic signals, Fourier transform for periodic signals, Properties of continuous time Fourier Transform, Systems characterized by constant coefficient differential equations Laplace Transform: Laplace transform, Region of convergence for Laplace transform, Inverse Laplace transform, Geometrical evaluation of Fourier Transform from pole-zero plot, Properties of Laplace transform, Analysis and characterization of LTI systems using Laplace transform Initial Conditions in Networks: First order differential equations- General and Particular solutions, Time constants, Initial conditions in elements, geometrical interpretation of derivatives, A procedure to evaluate initial conditions	
			----	**Section- C** Differential equation in circuits: Second order equations-Internal excitations, Networks excited by external energy sources, Response as related to the s-plane location of roots, General solutions in Terms of S, Q, ω_n Impedance Functions and Networks Theorems: The concept of complex frequency, Transform impedance and transform circuits, Series and parallel combinations of elements, Superposition and Reciprocity, Thevenin's Theorem and Norton's Theorem Two port Parameters: Relationship of two port variables, Short circuit admittance parameters, Open circuit impedance parameters, Transmission parameters, Hybrid parameters, Relation between parameter sets, Parallel connection of two port networks	

			---	**Recommended Books:** 1. Oppenheim A. V., A. V. &Nawab S. H. (2015). *Signal and Systems (2/e)*, Boston: Pearson Publication 2. Valkenburg M.E. Van (2015). *Network Analysis (3/e)*. New Delhi: Pearson Publication 3. Proakis J. G. &Manolakis D. G. (2007). *Digital Signal Processing: Principles, Algorithms, and Applications (4/e)*. New Delhi: Pearson Publication 4. Kuo F. F. (2010). *Network Analysis and Synthesis (2/e)*. New Delhi: John Wiley & Sons Publication **Suggested E-resources:** 1. **Circuit Theory** by Prof. S.C. Dutta Roy, Department of Electrical Engineering, Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/108102042/ 2. **Principles of Signals and Systems** by Prof. Aditya K. Jagannatham, Department of Electrical Engineering Indian Institute of Technology, Kanpur. https://nptel.ac.in/courses/108104100	
7	**Microwave Electronics**	After the completion of course student will be able to: • Understand various parameters of waveguide and use of component as per applications • Design impedance matching network for any transmission line or system	~~**Microwave Electronics**~~ **Section A** Introduction to Microwaves & its application, Transmission lines: General equation, input impedance, characteristic impedance, reflection and transmission coefficient, standing wave ratio, resonant and anti resonant line impedance matching, ~~smith chart and its applications~~, coaxial, ~~twin~~, strip &microstrip lines &baluns	**Microwave Engineering** **Section A** Introduction to Microwaves & its application, Microwave Electromagnetic spectrum, Transmission Lines: General equation, input impedance, characteristic impedance, reflection and transmission coefficient, standing wave ratio, resonant and anti-resonant line impedance matching, Matching techniques: single stub, double stub using smith chart, quarter wave transformer,baluns, coaxial transmission line, Planar transmission line:	Added Shifted ~~Deleted~~

		• Analyse and find applications and limitations of microwave tube Generators and Amplifiers		Strip line, Microstrip line, Slot line etc.	
			Section B Wave Guides: Wave propagation in rectangular & circular wave guides, wave guide modes~~, Q of wave guide~~, Wave guide coupling, Microwave passive components: S-parameter representation and analysis of microwave components such as Waveguide Tees, Two-hole directional coupler, attenuators, Phase shifters, Rectangular cavity resonator, Isolators, Circulators.	**Section B** Wave Guides: Wave propagation in rectangular wave guide: solution of TE and TM modes, Power Transmission and Attenuation, Excitation of modes in Rectangular waveguide, Circular Waveguide: Basic idea of TE and TM modes, Rectangular and Circular cavity resonators, Rectangular cavity resonators, Q of cavity resonators, S parameters and its conversion with Z and Y parameters, Wave guide coupling, Microwave passive Components: S- parameter representation and analysis of microwave components such as Waveguide Tees, Two-hole directional coupler, attenuators, Phase shifters, Microwave propagation in ferrites: Faraday rotation, Isolators, Circulators.	Added Shifted ~~Deleted~~
			Section C Microwave Tube Devices: Conventional Vacuum tubes at microwave, O type device - Klystron (two cavity & reflex). M type device magnetron, Introduction to TWT (Traveling Wave Tubes). Microwave Semiconductor Devices IMPATT, TRAPATT& Gunn Devices.	**Section C** Microwave Tubes: Limitations of Conventional vacuum tubes at microwave, Klystron: Construction and operation of two cavity and multi-cavity klystrons, Applegate Diagram and application of two cavity klystron, Construction and working of Reflex klystron, Magnetron: Types of magnetron, Construction, Operation and Analysis of cavity or travelling wave magnetron, Traveling wave tubes (TWT): Construction, Operation and practical consideration of helical type TWT, Applications of TWT, Microwave Semiconductor Devices: Tunnel diodes, principle of operation and application of tunnel diodes, Transferred Electron devices: Gunn-Effect diodes, Two-valley theory, Mode of operations of Gunn diode, Avalanche Transit-Time devices:	Added Shifted ~~Deleted~~

				IMPATT, TRAPATT.	
			Text Books: 1. Sisodia-Raghuvanshi: **Microwave Circuits & Passive Devices:** (Wiley-eastern).1st edition.1987 2. S.Y. Liao: **Microwave Devices & Circuits**, (Prentice Hall).1st Edition 1995, 3. Collins: **Foundation Of Microwave Engineering**, (Mc Graw Hill) 2nd Edition 1992 4. P.A. Rizzi: **Microwave:** (Prentice Hall). 1st Edition 1998	**Recommended Books:** 1. Liao, S.Y. (1995). *Microwave devices & Circuits*. New Delhi: Prentice Hall Publication. 2. Rizzi, P.A. (1998). *Microwave Engineering*. New Delhi: Prentice Hall Publication. 3. Collins, R. E. (1992). *Foundation of Microwave Engineering*. New Delhi: McGraw Hill Publication. 4. Pozar, David M. (2008). *Microwave Engineering*. New Delhi: Wiley Publication. **Suggested E- Recourses:** 1. **Microwave Theory and Techniques** by Prof. Girish Kumar, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101112/ 2. **Basic Building Blocks of Microwave Engineering** by Dr Amitabha Bhattacharya, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105130 3. **Transmission Lines and E.M. Waves** by Prof. R. K. Shivgaonkar, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/117101056/	
8	**Microwave Electronics Lab**	After completion of this laboratory course, students will be able to: • Understand the concept and working of microwave bench and different components connected on a bench. • Analyze the behaviour of various microwave components.	~~**Microwave Electronics Lab**~~ 1. Determine the operating frequency of reflex klystron. 2. Draw the V-I characteristics of Reflex klystron 3. Draw the characteristics of attenuator 4. To verify the wave-guide law 5. To study the directivity and coupling coefficient of Directional Coupler. 6. To study the properties of magic Tea and also determine isolation and coupling coefficient.	**Microwave Engineering Lab** 1. Determine the operating frequency of reflex klystron. 2. Draw the V-I characteristics of Reflex klystron 3. Draw the characteristics of attenuator 4. To verify the wave-guide law 5. To study the directivity and coupling coefficient of Directional Coupler. 6. To study the properties of magic Tea and also determine isolation and coupling coefficient.	**Learning Outcomes added.** **No Change in Experiment List.**

		• Verify properties/ characteristic of microwave source, tees and directional coupler.	7. To Measure the VSWR of (i) Short circuit (ii) Open circuit (iii) Matched Load (iv) Unmatched Load. 8. To study the properties of E-plane and H-plane Tea. Determine isolation and coupling coefficient	7. To Measure the VSWR of (i) Short circuit (ii) Open circuit (iii) Matched Load (iv) Unmatched Load. 8. To study the properties of E-plane and H-plane Tea. Determine isolation and coupling coefficient	
9	**EIE 201, Electronics Measurement and Instrumentation**	After the completion of course student will be able to: • Measure various electrical parameters with precision and accuracy. • Select appropriate transducers for measurement of physical parameter. • Use suitable AC Bridge for relevant parameter measurement.	**~~EIE 201, Electronics Measurement and Instrumentation~~** **Section A** Measurements, Elements of Measurements, Mathematical Models of Measurements system, Performance Characteristics, Error in Measurement, True value, static error, static correction, scale range, scale spam, Reproducibility & drift, Repeatability, ~~Noise-Signal to noise ratio, source of noise, Johnson noise, noise factor & noise figure.~~ Accuracy & precision, Indication of precision, Significant figures, Range of doubt, static sensitivity, linearity, Hysteresis, Threshold, dead time, dead zone, resolution & discrimination, measurement error type & analysis, standard & calibration, curve fitting.	**Electrical and Electronics Measurements** **Section A** Measurements: Elements of Measurements, Performance characteristics, Error in measurements, True value, Static error, Static correction, Scale range, Scale span, Reproducibility, Drift, Repeatability, Accuracy and Precision, Indication of Precision, Significant figures, Range of doubt, Static sensitivity, Linearity, Hysteresis, Threshold, Dead Time, Dead zone, Resolution and Discrimination. Measurement error: Types and analysis, Loading error due to series and shunt connected instruments, Standards and Calibration, Curve fitting, Dynamic characteristics of measurement systems, Mathematical models of measurement system (Mechanical and Electrical System). Transducers: Classification and characteristics, Resistive, Capacitive, Inductive, Hall Effect. Measurement of Displacement: LVDT and RVDT, Strain Gauges and its types. Measurement of Temperature: RTD, Thermistor and Thermocouples.	**Added** **Shifted** **~~Deleted~~**
			SECTION B Transducers: Classification, resistive, capacitive, inductive, ~~Piezoelectric,~~	**Section B** d'Arsonval Galvanometer- Construction, Torque Equation and Dynamic behavior of	**Added** **Shifted**

			~~thermoelectric,~~ ~~photoelectric,~~ Hall Effect. Measurements of displacement- linear & rotational (LVDT&RVDT), Strain gauge, Types of Strain gauge. ~~Measurement of Velocity- Linear & Angular.~~ Measurement of Temperature- RTD, Thermistor, thermocouple, ~~Pyrometer-Radiation & optical, Platinum Resistance thermometer. Measurement of flow- Electromagnetic & ultrasonic type. Measurement of Liquid- Gamma rays, ultrasonic type. Measurement of Humidity- Hydrometer, Measurement of P_H - P_H electrode,~~ Measurement of Phase &Frequency- Lissouge Pattern.	galvanometers, PMMC Instrument- Construction, Torque equation, Ammeter shunts, Voltmeter multipliers, Ohmmeter- Series and Shunt type, Moving Iron Instruments, Electrodynamometer Instrument. AC Bridges- Measurement of self-inductance (Maxwell's Bridge, Hay's Bridge, Owen's Bridge, Anderson's Bridge), capacitance (De Sauty's and Schering Bridge) and frequency (Wien's Bridge).	**~~Deleted~~**
			SECTION C AC Bridges- Measurement of self-inductance, capacitance & Frequency, Measuring Instruments: ~~Construction of Ballistic Galvanometer,~~ PMMC instruments- Construction & Torque equation, Moving Iron- Construction & Torque equation, ~~DC & AC voltmeters, DC & AC ammeters~~, ohmmeters-series & Shunt type, Multimeter- Digital & Analog, Cathode Ray Oscilloscope- CRT, ~~Electron Gun, Focusing, Deflection~~, Time base Generator, Types of CRO, Function generator, Q- meter, ~~Energy meter~~.	**Section C** Measurement of low, medium and high resistance. Multimeter- Analog and Digital, Function generator, Wave Analyzer, Spectrum Analyzer, Q-meter and its applications, CRO- CRT, Time base generator, Measurement of Phase and Frequency (Lissajous Patterns), types of CRO (Dual Trace, Dual Beam, Sampling type and Storage CRO).	**Added** **Shifted** **~~Deleted~~**
			Text Books: 1. Sawhney, A.K.: **A Text Book on Electrical and Electronics measurements and Instrumentation:**Dhanpat Rai & Sons, 4^{th} edition 1968. Reprint 2004. 2. ~~Doeblin, Ernest O: Measurement system: **Application and Design:** Mc Graw Hill New York, 4^{th} edition 1990.~~	**Recommended Books:** 1. Sawhney A.K. (2015). *A Course in Electrical and Electronic Measurements and Instrumentation.* New Delhi: Dhanpat Rai & Co Publication 2. Jain R.K. (2008). *Mechanical and Industrial Measurement.* New Delhi: Khanna Publishers 3. Nakra B.C. & Chaudhry K.K. (2013).	**Added** **~~Deleted~~**

			Reference Books: 1. ~~Jones, Barney E: **Instrumentation measurement and Feedback:**TMH, edition 1978, reprint 2004.~~ 2. ~~Cooper, W.D: **Modern Electronics instrumentation and Measurements:** PHI.~~ 3. R.K Jain: **Mechanical industrial Measurements**: Khanna Publishers.	*Instrumentation, Measurement and Analysis.* New Delhi: Tata McGraw Hill Publication 4. Kalsi H.S. (2017). *Electronic Instrumentation.* New Delhi: Tata McGraw Hill Publication 5. Singh S.K.(2010). *Industrial Instrumentation and Control.* New Delhi: Tata McGraw Hill Publication **Suggested e-Resource:** **1. Industrial Instrumentation** by Prof.Alok Barua, Department of Electrical Engineering, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105064	
10	**Electrical and Electronics Measurements Lab**	After completion of this laboratory course, students will be able to: • Develop an understanding of construction and working of different measuring instruments • Develop an ability to use measuring instruments and AC and DC bridges for relevant measurement • Select appropriate passive or active transducers for measurement of physical phenomenon.	**____**	1. To study Hall Effect. 2. To study principle of Thermocouple. 3. To study principle of Load cell. 4. To study principle of Thermistor. 5. To study principle of strain guage. 6. To study Principle of LVDT 7. To study De sauty bridge. 8. To study Wein AC bridge. 9. To study CRO circuitry in detail.	**Learning outcomes added.**
11	**EIE 302, Control Systems**	After the completion of course student will be able to: • Formulate mathematical model	**Section A** Open loop and closed loop systems, servomechanism, mathematical model of systems, differential equations and transfer functions, Block diagram algebra, signal flow graphs; +ve and -ve feedback effects of	**Section A** Open loop and closed loop systems, servomechanism, mathematical model of systems, differential equations and transfer functions, Block diagram algebra, signal flow graphs; +ve and -ve feedback effects	**Added** **Shifted** ~~**Deleted**~~

		for physical systems and simplify representation of complex systems using reduction techniques. • Use standard test signals to identify performance characteristics of first and second-order systems. • Apply root locus technique for stability analysis.	feedback, ~~servo- components, DC and AC servomotors, Techogenerators, synchors, stepper motor, op-amp, potentiometer as an error detector; comparison of AC and DC servomechanism.~~	of feedback. Standard test signals, time response of first and second order systems, steady state errors and error constants, Design specifications of second order systems.	
			Section B Standard test signals, time response of first and second order systems, steady state errors and error constants, Design specifications of second order systems, effects of derivative and integral error compensation, PID controller, Design considerations for higher order systems in brief, performance indices. Concept of stability, necessary conditions for stability, Routh Hurwitz stability criterion, relative stability criterion, relative stability in terms of Routh Hurwitz criterion; Root-locus technique.	**Section B** Effects of derivative and integral error compensation, PID controller, Design considerations for higher order systems in brief, performance indices. Concept of stability, necessary conditions for stability, Routh Hurwitz stability criterion, relative stability criterion, relative stability in terms of Routh Hurwitz criterion; Root-locus technique. Correlation between time and frequency response specifications; Frequency domain plots, polar plots.	**Added** **Shifted** ~~**Deleted**~~
			Section C Correlation between time and frequency response specifications; Frequency domain plots, polar plots,Bode plot, log magnitude versus phase plots; Gain-margin, Phase-margin, Nyquist stability criterion; Constant-M and constant-N circles; closed loop frequency response from these. Preliminary considerations of classical design, cascade and feedback compensation, time-domain design using lag, lead and lag lead compensation, frequency domain design using lag.	**Section C** Bode plot, log magnitude versus phase plots; Gain-margin, Phase-margin, Nyquist stability criterion; Constant-M and constant-N circles; closed loop frequency response from these. Preliminary considerations of classical design, cascade and feedback compensation, time-domain design using lag, lead and lag lead compensation, frequency domain design using lag. State Variable model and solution of state equation of LTI systems.	**Added** **Shifted** ~~**Deleted**~~
			Text/ReferenceBooks: 1. I.J. Nagrath and M. Gopal: **Control System & Engineering 2nd Ed.:** Wiley Eastern Ltd.,1985. 2. Katsushiko Ogata: **Modern Control Engineering 3rd**	**Recommended Books:** 1. Nagrath, I. J. (2006). *Control systems engineering*. New Delhi: New Age International. 2. Ogata, K., & Yang, Y. (2002). Modern control engineering (Vol. 4). India:	

			Ed.: Printice Hall of India Pvt. Ltd., 2001	Prentice hall. **Suggested e-resource:** 1. Control System by Prof. S. D. Agashe, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101037/	
12	**Control Systems Lab**	After completion of this laboratory course, students will be able to: • Understand the concept of time response and frequency response of any physical system. • Mathematical modeling of physical system to find out of transfer system. • Analyze the stability of system with the help of system response.	~~1. To study and controlling action using PID controller and calculate the first overshoot temperature and plot the graph.~~ ~~2. To study the DC position controller and find out the tachometer gain.~~	1. To study and controlling action using PID controller and calculate the first overshoot temperature and plot the graph. 2. To study the DC position controller and find out the tachometer gain. 3. To determine time domain response of a second order systems for step input and obtain performance parameters. 4. To convert transfer function of a system into state space form and vice-versa. 5. To plot root locus diagram of an open loop transfer function and determine range of gain 'k for stability. 6. To plot a Bode diagram of an open loop transfer function. **7.** To draw a Nyquist plot of an open loop transfers function and examine the stability of the system.	**Learning Outcomes added.** **~~Deleted~~** **Added**
13	**MGMT 209, Entrepreneurship**	----	—	----	**Please refer from Department of Management**
14	**TSKL 403, Communication Skills**	----	-----	-----	**Please refer from Department of English**
15	**Seminar**	After the completion of course student will be able to: • To identify promising new directions of various cutting edge	-----	------	**Learning Outcomes added.**

		technologies. • Undertake a critical review of the literature. • Deliver well-organized technical presentations and prepare a technical report.			
16	**VLSI 401, VLSI Design**	After the completion of course student will be able to: • Explain the basic theory of crystal growth, wafer fabrication and IC fabrication technology. • Explain the different VLSI design styles, overview of ICs and fabrication steps of MOS, CMOS and BJT. • Design and analyse the output characteristics of different MOS inverters	---	---	**No change in course contents**
			Text Books: 1. Sze S.M.: **VLSI Technology:**TMH. 2. Kang S.M., Leblebici Y: **CMOS digital Integrated Circuits: Analysis & Design** : Mc. Graw Hill. **Reference Books:** 1. Botker B.R: **Microelectronics.** 2. Gandhi S.K.: **VLSI Fabrication Principle.** 3. Plummer J., Deal M., Griffin P.: **Silicon VLSI Technology**: Prentice Hall. 4. Sarrafazadeh M. & Wong C.K.: **An introduction to VLSI Physical Design:** Mc Graw Hill. 5. Martin Ken: **Digital Integrated Circuits:** Oxford press. 6. Neil H.E. Weste& Kamran Eshraghian: **Principle of CMOS VLSI Design.**	**Recommended Books:** 1. *Sze, S.M.(2017). VLSI Technology*. New Delhi*:* TMH Publication. 2. Kang, S.M., & Leblebici, Y. (2002). *CMOS digital Integrated Circuits Analysis & Design*. New Delhi: McGraw Hill Publications. 3. Botkar, K. R. (2004). *Integrated Circuits*. New Delhi: Khanna Publishers. 4. Gandhi, S.K. (1994). *VLSI Fabrication Principle Silicon and Gallium Arsenide*. New Delhi: Willey Publications. 5. Plummer, J., Deal, M., & Griffin, P. (2000). *Silicon VLSI Technology: Fundamentals, Practice and Modeling*. New Delhi: Pearson Publications. 6. Sarrafazadeh, M.,& Wong, C.K. (1996). *An introduction to VLSI Physical Design*. New Delhi: McGraw Hill Publication. 7. Ken, Martin. (1999). *Digital Integrated Circuits Design.* New York, United State: Oxford University Press. 8. Neil, H.E., Weste, &Eshraghian, Kamran (1994). *Principle of CMOS VLSI Design*. Boston, New York: Addison Wesley Publication.	

				Suggested E-Resources: 1. **VLSI Circuits** by Prof. S. Srinivasan, Department of Electrical Engineering, IIT-Madras. https://nptel.ac.in/courses/117106092/1 2. **VLSI Technology** by Dr. Nandita Das Gupta, Department of Electrical Engineering, IIT-Madras. https://nptel.ac.in/courses/117101058/	
17	**VLSI Design Lab**	After completion of this laboratory course, students will be able to: • Use VHDL for design of digital circuits • Model complex digital systems at several level of abstractions; behavioral and structural, synthesis and rapid system prototyping. • Develop and simulate register-level models of hierarchical digital systems	~~**Silvaco**~~ ~~1. Model the fabrication process flow of NMOS with I/V characteristics curve~~ ~~2. Model the fabrication process flow of PMOS with I/V characteristics curve~~ ~~3. Model the fabrication process flow of NPN/PNP mos based transistor with input/output characteristics curve.~~ ~~4. Model the fabrication process flow of pn junction diode.~~	1. Write a program for the implementation of half adder and Full adder. 2. Write a program for implementing half subtractor and full subtractor. 3. Write a program for implementing MUX 4x1 and DEMUX (1X4) 4. Write a program for implementing Encoder and Decoder. 5. Write a program to implement gray code to binary code converter and vice versa. 6. Write a program to implement COMPARATOR. 7. Write a program for the implementation of S-R Flip flop and D Flip flop. 8. Write a program for the implement up-counter and down-counter. 9. Write a program to design JK Flip-flop and write design summary 10. Write a program to design T Flip-flop and write design summary	**Learning Outcomes added.** **Added**
18	**CS 209, Data Structures**	___	-----	-------	**Please refer from Department of Computer Science**
19	**Analog Communication**	After the completion of course student will be able	**Section-A** ~~Introduction — Communication Process,~~	**Section-A** Introduction to signals: Size of signals,	Added

		to: • Explain different blocks in communication system and how noise affects communication using different parameters. • Distinguish between different amplitude modulation schemes with their advantages, disadvantages and applications and analyse generation and detection of FM signal and comparison between amplitude and angle modulation schemes. • Identify different types of radio receiver circuits	~~Source of Information, Channels-Noise, System Noise Source, Noise & Feed- back, Noise Figure, Electromagnetic Spectra. Base band and pass band signals,~~Modulation Process – Need,~~Bandwidth, Requirements- Frequency Spectra of Non-sinusoidal Signals, Analogue vs Digital Communication, Continuous and Discrete Spectra, Band pass System,~~	Classification of signals, Some useful signal operations, Unit impulse function, Signals and vectors, Signal comparison-correlation, Signal representation by orthogonal signal set, Trigonometric Fourier series, Exponential Fourier series Analysis and Transmission of Signals: Fourier transform of some useful signals, Some properties of Fourier Transform, Signal Transmission through linear system, Ideal and practical filters, Signal distortion over a communication channel, Signal energy and energy spectral density, Signal power and power spectral density.	Shifted ~~Deleted~~
			Section B Modulation: Amplitude Modulation : Basic Principles, Mathematical Relationships, Frequency Modulation and Phase Modulation – Basic Principles, Mathematical Relationships, Comparison between Amplitude Modulation and Angle Modulation, Spectral Analysis of Different Modulation; Modulators: Amplitude Modulator, Suppressed Carrier DSB Modulator, Balanced Modulator, SSB Modulators: Filter Method, Phase-shift Method & Third Method-ISB Modulators, Vestigial sideband Modulator; Frequency Modulator: Direct &Indirect Method, Narrow band FM, Phase Modulator, Spectral Analysis of these Modulators; Transmitters – AM Transmitter, ~~Low Level and High Level SSB Transmitter,~~ Pilot Carrier – FM Transmitter – Narrow band and Wide band, FM Stereo Transmitter;	**Section- B** Amplitude Modulation: Baseband and carrier communication, Double sideband modulation, Single sideband modulation, Quadrature amplitude modulation, Vestigial sideband modulation, Carrier acquisition, Superheterodyne receiver Angle Modulation: Concept of instantaneous frequency, Bandwidth of angle modulated waves, Generation of FM waves, Demodulation of FM, Interference in angle modulated systems, FM receiver	Added Shifted ~~Deleted~~
			Section C ~~Receiver:- Sensitivity, Selectivity,~~Signal to Noise Ratio, Demodulators – Diode Detector; FM Detectors, ~~Phase Detector- Ratio Detector – Foster – Seelay Discriminator; AM~~	**Section-C** Random Signal and Noise: Gaussian Noise, Bandpass noise and its representation, Noise power, SNR ratio, PSD of white noise.	Added Shifted ~~Deleted~~

			~~Receiver — (Block Level Treatment) — TRFReceiver,~~Super-heterodyne Receiver,~~Double Super-heterodyne Receiver,~~SSBReceiver,~~Communication Receiver, AGC Circuitry; FM Receiver – FM Stereo Receiver (Block Level) Carrier Shareholding,~~ Capture Effect.	Analog Systems in The Presence of Noise: Baseband system, Double sideband modulation- Suppressed carrier, Single sideband modulation- Suppressed carrier, Amplitude modulation, Angle modulated systems- Phase and Frequency modulation, Optimum pre-emphasis-deemphasis systems Systems and Noise Calculations: Electrical Noise, Noise Figure, Equivalent Noise Temperature, Cascade Connection of Two-Port Networks, Free-Space Link Calculations	
			Text Books: 1. ~~George Kennedy: **Electronic Communications Systems:**~~McGraw Hill. 2. Taub and Schilling: **Principles of communication systems:**McGraw Hill. 3. ~~Martin S Roden: **Analog and digital Communication systems.**~~ 4. ~~Sol Lapatine: **Electronic communication.**~~ 5. ~~Dennis Roody and JhonCoolen: **Electronic communication** Prentice Hall.~~ ~~6. J Dunlop & D G Smith: **Elecommunication Engineering.**~~	**Recommended Books:** 1. Lathi, B.P., Ding, Zhi.,& Gupta, Hari Mohan. (1998). *Modern Digital and Analog Communication Systems*. New Delhi: Oxford University Press 2. Haykin, S. & Moher, M. (2007).*Introduction to Analog and Digital Communication*. New York, United States: John Wiley & Sons. 3. Shilling, D.L., &Taub, H. (2008). *Principles of Communication Systems*. New Delhi: Mc Graw Hill Publication. **Suggested E-Resource:** 1. **Analog Communication** by Prof.Goutam Das, G S Sanyal School of Telecommunications, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105143/	Added ~~Deleted~~
20	**Analog Communication Lab**	After completion of this laboratory course, students will be able to: • Demonstrate Amplitude modulation and demodulation techniques. • Demonstrate frequency modulation	----	-----	**Learning outcomes added.** **No change in experiment list.**

		and demodulation technique. • Analyze generation and detection of FM signal and comparison between amplitude and angle modulation schemes. • Compare different modulations and demodulations to recognize the advantages and disadvantages of them. • Identify different radio receiver circuits and role of AGC.			
21	**ELE 306, Microprocessors and Microcontrollers**	After the completion of course student will be able to: • Interface memory and different peripherals with Microprocessor and microcontroller • Design and develop the system for real time applications	**---**	**---**	**No change in course contents**
			Test Books : 1. Kenneth J Ayala, **"The 8051 Micro Controller Architecture, Programming and Applications",** Thomson Publishers, 2nd Edition. 2. D.V.Hall, **"Micro Processor and Interfacing"**, Tata McGraw-Hill. **Reference Book :** 1. Ajay V. Deshmukh, "Microcontrollers - theory applications", Tata McGraw-Hill Companies-2005. 2. Ray and Bhurchandi. "Advanced Micro Processors", Tata McGraw Hill. 3. Kenneth J. Ayala, "The 8086 Micro Processors Architecture, Programming and Applications", Thomson Publishers, 2005. 4. Microcomputer Systems: The 8086/8086 Family: Architecture, Programming and Design, 2nd ed., Liu & Gibson.	**Recommended Books:** 1. Kenneth, J. Ayala.(2004). *The 8051 Micro Controller Architecture, Programming and Applications.* New Delhi: Cengage Learning Publication 2. Hall, D.V. (2017). *Micro Processor and Interfacing.* New Delhi: McGraw-Hill Publication. 3. Deshmukh, Ajay V. (2005). *Microcontrollers – Theory and Applications.* New Delhi: McGraw Hill Publication. 4. Ray, A.K., &Bhurchandi, B.H. (2017). *Advanced Micro Processors*. New Delhi: McGraw-Hill Publication. 5. Kenneth, J. Ayala. (2011). *The 8086 Micro Processors Architecture, Programming and Applications.* New Delhi: Prentice Hall India. **6.** Liu, Yu Cheng., & Gibson, A. (1985). *Microcomputer Systems: The*	

				8086/8086 Family: Architecture, Programming and Design. New Delhi: Prentice Hall India. **Suggested E-Resources:** 1. **Microprocessors and Microcontrollers** by Prof.SantanuChattopadhyay, Department of E&EC Engineering, IIT Kharagpur. https://nptel.ac.in/courses/108105102/ 2. **Microprocessors and Microcontrollers** by Prof. Krishna Kumar, IISC Bangalore https://nptel.ac.in/courses/106108100/	
22	**ELE 306L, Microprocessors and Microcontrollers Lab**	After completion of this laboratory course, students will be able to: • Understand the different instructions of 8086 microprocessor assembly language. • Coding in assembly language. • Solve different real time problems.	**----**	-----	**Learning Outcomes added.** **No Change in Experiment List.**
23	**Project**	After completion of this course, students will be able to: • Demonstrate effective project execution and control techniques that result in successful projects. • Ability to identify, formulates, and solves engineering problems. • Use the techniques,	**----**	-----	**Learning Outcomes Added and this course has no prescribed syllabus**

		skills and modern engineering tools necessary for engineering practice			
24	**UIL Project**	After completion of this course, students will be able to: • Undertake problem identification, formulation and solution. • Design engineering solutions to complex problems utilizing a systems approach. • Demonstrate the knowledge, skills and attitudes of a professional engineer. • Demonstrate effective organizational leadership and change skills for managing projects, project teams, and stakeholders.	------	------	**Learning Outcomes Added and this course has no prescribed syllabus**
25	**Biomedical Instrumentation**	After the completion of course student will be able to: • Describe the principle of interfacing of Electrode-electrolyte and different types of electrodes which are used in biomedical field. • Explain different types of recorders and photometers. • Describe the method of measurement of BP	---- ----	**Section A** Electrode electrolyte interface, half-cell potential, polarization and non- polarisable electrode, calomel electrode, needle and wire electrode, microelectrode-metal micropipette. Ag/AgCl electrodes Microelectrodes, skin surface electrode, and lead for EG, ECG, EMG. Transducer for biomedical applications, factors governing the selection of transducer, pressure, temperature, flow, biomedical ultrasonic transducer. **Section B** Low-Noise preamplifier, main amplifier	**Addition of New Course as Elective**

		and blood flow.		and driver amplifier, inkjet recorder, thermal array recorder, photographic recorder, magnetic tape recorder, X-Y recorder, medical oscilloscope. pH, PO2, PCO2, pHCO3, Electrophoresis, colorimeter, spectro photometer, flame photometer, auto analyzer.	
			---	**Section C** Respiration, heart rate, temperature, pulse blood pressure, cardiac output, O2, CO2 measurements. Measurement of blood pressure, blood flow, and heart sound, cardiograph: Phonocardiography, vector cardiograph, Echocardiography pacemaker, defibrillators, Ventilator, Computer patient monitoring system.	
			---	**Recommended Books:** 1. Cromwell L. (2007). *Biomedical Instrumentation and Measurement.* New Delhi: PHI Publication 2. Webster J.G.(1998). *Medical Instrumentation Application and Design*. New York: John Wiley and Sons 3. KhandpurR.S. (1997). *Handbook of Biomedical Instrumentation*. New Delhi: Tata McGraw-Hill Publication 4. Carr J. J. & Brown J. M. (1997). *Introduction to Biomedical Equipment Technology*. New York*:* John Wiley and Sons	
26	**Optical Network**	After the completion of course student will be able to: • Describe the important components such as multiplexer, filters. • Explain the	-----	**Section A** Introduction to Optical Networks, Characteristics of Optical Fiber (Emphasis on Non Linear Characteristics) Timing & Synchronization, Components: Couplers, Isolators & Circulators, Multiplexers & Filters, Optical Amplifiers, Tunable Lasers, Switches, Wavelength Converters,	**Addition of New Course as Elective**

		multiplexing technique • Describe the protection technique in SONET/SDH and IP network		Networks SONET/SDH, Multiplexing, SONET/ SDH Layers, Frame, Structure, Frame Structure, Physical Layer, Elements of a SONET/SDH Infrastructure	
			-----	**Section B** ATM : Functions of ATM, Adaptation Layers, Quality of Service, Flow Control, Signaling and Routing, WDM Network Elements, Optical Line Terminals, Optical Line Amplifiers, Optical Add/ Drop Multiplexers, Optical Cross Connects, WDM Network Design, Cost Trade-offs, Light path Topology Design, and Routing and wavelength assignment problems, Dimensioning Wavelength Routing Networks,	
			------	**Section C** Network Survivability Basic Concepts, Protection in SONET/SDH, Protection in IP networks, Optical Layer Protection, Different Schemes, Interworking between Layers Access Networks, Network Architecture Overview, Enhanced HFC, FTTC, Optical Switching, OTDM, Synchronization, Header Processing, Buffering, Burst Switching. Deployment Considerations	
			----	**Recommended Books:** 1. Ramaswami, Rajiv.,&Sivarajan, Kumar. N.(2009). *Optical Networks: A Practical Perspective*. San Francisco, California: Morgan Kaufmann Publisher. **2.** Uyless, Black. (2009). *Optical Networks Third Generation Transport Systems***:** New Delhi: Pearson Publication. **3.** Tanenbaum, Andrew. S. (2010).	

				*Computer Networks***.** New Delhi: Pearson Publication. **4.** Murthy, C. Siva Ram.,&Gurusamy Mohan. (2001). WDM, Optical Networks Concepts, Design & Algorithms**.** New Delhi: Pearson Publication. **Suggested e-resources:** **1. Introduction to Optical Networks** by YatindraNath Singh, Department of Electrical Engineering, Indian Institute of Technology, Kanpur. http://home.iitk.ac.in/~ynsingh/seminars/OptNets.pdf **2. Optical networks and Switching Systems** by Prof.Yatindra N Singh, Department of Electrical Engineering Indian Institute of Technology, Kanpur. https://nptel.ac.in/syllabus/117104021	
27	**Satellite Communication**	After the completion of course student will be able to: • Identify the fundamentals of orbital mechanics, the characteristics of common orbits used by communications and other satellites, and be able to discuss launch methods and technologies. • Understand the systems required by a communications satellite to function and the trade-offs and limitations encountered in the design of a	---- ----	**Section A** Elements of Satellite Communication, Orbital mechanics, look angle and orbit determination, launches & launch vehicle, orbital effects, Geostationary Orbit, Satellite subsystems, attitude and orbit control systems, TTC&M, communication subsystem, satellite antenna, satellite link design: basic transmission theory, system noise temperature and G/T ratio, downlink design, uplink design, satellite systems using small earth station, design for specified C/N. **Section B** Modulation and multiplexing techniques for satellite links: FM, pre-emphasis and de-emphasis, S/N ratios for FM video transmission, digital transmission, digital modulation and demodulation, TDM. Multiple access: FDMA, TDMA, DAMA	**Addition of New Course as Elective**

		communications satellite system. • Understand different Networks topologies and applications of networks, as well as the comparison to alternative communications systems.		and CDMA.	
			---	**Section C** Error control for digital satellite links: error detection and correction, channel capacity, error control coding, convolutional codes, linear and cyclic block codes. Propagation effects and their impact on satellite-earth links: attenuation and depolarization, atmospheric absorption, rain, cloud and ice effects etc. Introduction of various satellite systems: VSAT, low earth orbit and non-geostationary, direct broadcast satellite television and radio, satellite navigation and the global positioning systems.	
			---	**Recommended Books:** 1. Bostian,Charles., Pratt, Timothy., & Allnutt, Jeremy. (2006). *Satellite Communications***.** New Delhi: John Wiley & Sons. 2. Roddy, Dennis. (2017). *Satellite Communications***.** New Delhi: McGraw-Hill Publication 3. Ha, Tri. T. (1990). *Digital Satellite Communications.* New Delhi: McGraw-Hill Publication **Suggested e-resources:** 1. **Satellite Communication Systems** by Prof.Kalyan Kumar Bandyopadhyay Department of Electronics and Electrical Communication Engineering Indian Institute of Technology, Kharagpur. http://textofvideo.nptel.ac.in/117105131/lec1.pdf 2. **Satellite Link Design** by Dr. Marwah Ahmed. https://net425site.files.wordpress.com/2017/02/net-425-d-feb-2016-lec-5.pdf	

28	**Basics of Nanoelectronics**	After the completion of course student will be able to: • Explain the fundamental science and quantum mechanics behind nanoelectronics. • Explain the basic concepts behind the operation of nano scale MOSFET • describe the various techniques and approaches for the fabrication of nano-scale devices	---	**Section A** The 'Top down' and 'Bottom up' approach, Nanotechnology potential, introductory quantum mechanics for Nanoscience: size effect in smaller systems, quantum behavior of nanometric world, Band structure and density of states at Nanoscale: energy bands, density of states at low dimensional structure. Semiconductor heterostructure quantum wells, quantum wires, and quantum dots.	**Addition of New Course as Elective**
			--	**Section B** MOS band structure, CMOS Scaling, The nanoscale MOSFET, Finfets, Vertical MOSFETs, limits to scaling, Tunnel junction and application of tunneling: Tunneling through a potential barrier, potential energy profiles of material interfaces,Classical and semi-classical transport, ballistic transport, carbon nanotubes,Single electron transistor, Coulomb Blockade, Resonant Tunneling diodes and transistors.	
			---	**Section C** Buck minsterfullerence, Nanodiomond, Molecular Machine, Nanobiometrics. **Fabrication technology**: Top-down vs. bottom-up technology. **Lithographic process**: Lithography, Nanolithography, split gate technology, self-assembly, limitation of lithographic process. **Non-lithographic techniques:** Plasma arc discharge, sputtering, evaporation, chemical vapour deposition, pulsed laser deposition, molecular beam epitaxy, sol-gel technique, electro deposition and other process.	
			---	**Recommended Books:** 1. Hanson, G. W. (2008). *Fundamentals*	

				of Nanoelectronics. New Delhi: Pearson Publication. 2. Chattopadhyay ,K. K.,& Banerjee, A. N. (2009). *Introduction to Nanoscience and Nanotechnology*. New Delhi: PHI Publication. 3. Mitin, Vlaadiniz.U. (2009). *Introduction to Nanoelectronics*. New Delhi: Cambridge University Press. 4. Dragman,M., &Dragman,D. (2008). *Nanoelectronics- Principles and Devices (2/e*): Artech House Publishers 5. Goser, Karl. (2004). *Nanoelectronics and Nanosystems*. Berlin: Springer Publication 6. Minoli, Daniel. (2005). *Nanotechnology Application to Telecommunication and Networking*. Hoboken, New Jersey: Wiley Publication. 7. Davis ,John. H. (1997). *Physics of Low Dimension Semiconductor*. New Delhi: Cambridge University Press. 8. Cosh, Carl.C. (1998). *Nanostructure Materials Processing Property and Applications*. Norwich, New York: Noyes Publications	
29	**Mobile Communication**	After the completion of course student will be able to: • To understand the various generations of mobile communications and basics of wireless communication • To understand the concept of cellular communication • Can conduct field	----	**Section A** Introduction to Wireless Communication System: Evolution of mobile radio communication, Mobile radiotelephony in U.S Mobile radio system around the world, second generation (2G) cellular network, evolution to 2 5G wireless network evolution for 2.5G TDMA standards, third generation (3G) wireless network. The Cellular concept- System design fundamentals, frequency reuse channel, assignment strategies. Hand off strategies Interference and system capacity,	**Addition of New Course as Elective**

		experiments and measurements		improving coverage and capacity in cellular system.	
			----	**Section B** Propagation model and Spread Spectrum Modulation Techniques: Longley rice model, kumara model hata model pcs extension to hata model, wolfish and betony model, Pseudo Noise (PN) sequence,. Direct sequence spread spectrum (DSSS), frequency hopped spread spectrum (FHSS). Multiple Access Techniques for Wireless Communication, Introduction to multiple access. Frequency division multiple access (FDMA) Time division Multiple access (TDMA).	
			----	**Section C** Spread spectrum multiple access. Packet Radio. Global System for Mobile Communication, channel types, Example of a GSM cell. Frame structure of GSM, Data over low power wireless Re-cordless Network.	
			----	**Recommended Books:** 1. Rappaport,Theodre. S. (2014) *Wireless Communication***.** New Delhi: Pearson Publication. 2. Pandya, Raj. (1999). *Mobile and Personal Communication System and Services***:** New Delhi: PHI Publication. 3. Goddman, David.J. (1997). *Wireless Personal Communication System***:** Addition Wesley Publication. 4. Tesal, Joachim. (1997). *GSM cellular Radio***:** New Delhi: John Wiley Publication **Suggested E-Resources:** 1.**Wireless Communications** by Prof.Dr.Ranjan Bose, Department of Electrical Engineering, IIT Delhi.	

				https://nptel.ac.in/courses/117102062/	
30	**Radar Navigation**	After the completion of course student will be able to: • Understand the basic concept of Radar and applications of various types. • Understand the different Radar Performance factors. • Explain the operation of CW& FM Radar.	----	**Section A** RADAR SIGNAL MODELS: Amplitude models, distributed target forms of range equation, radar cross section, statistical description of radar cross section, Swerling model, Clutter, signal to clutter ratio, temporal and spatial correlation of clutter, noise model and signal to noise ratio, frequency models, Doppler shift, simplifies approach to Doppler shift, stop and hop assumption, spatial model, variation with angle, variation with range, projections, multipath, spectral models. RADAR WAVE FORMS: Waveform matched filter of moving targets, ambiguity function, ambiguity function of the simple matched pulse filter for the pulse burst, pulse by pulse processing, range ambiguity, Doppler response and ambiguity function of the pulse burst.	**Addition of New Course as Elective**
			----	**Section B** DETECTION FUNDAMENTALS: Radar detection as hypothesis testing, Neyman-Pearson detection rule, likelihood ratio test, threshold detection of radar signals, non-coherent integration of nonfluctuating targets, Albersheim and Shnidaman equations, Binary integration. RADIO DIRECTION FINDING: loop direction finder, goniometer, errors in direction finding, adcock and automatic direction finders, commutated aerial direction finder. RADIO RANGES: LF/MF four course radio range, VOR, ground equipment & receiver, VOR errors. HYBERBOLIC SYSTEM OF NAVIGATION: LORAN Decca & Omega system.DME&TECAN.	

			---	**Section C** AIDS TO APPROACH AND LANDING: ILS, GCA& MLS DOPPLER NAVIGATION: Beam configuration, doppler frequency equation, track stabilisation and doppler spectrum, components of doppler navigation system, doppler radar equipment, CW &FMCW Doppler radar, frequency trackers, doppler range equation. SATALLITE NAVIGATION SYSTEM: transit system, NAVSTAR, GPS, basic principles of operation, signal structure of NAVSTAR broadcasts, data message, velocity determination, accuracy of GPS & differential navigation, NAVSTAR receiver.	
			---	**Recommended Books:** 1. Richards, Mark. A (2014). *Fundamentals of Radar Signal Processing*. New Delhi:TMH Publication. 2. Nagraja, N. S. (2009). *Elements of Electronics Navigation*: New Delhi:TMH Publication. 3. Peebles Jr. P. Z. (1998). *Radar Principles*. New Delhi: Wiley Publication. **Suggested E-Resources:** **1. Introduction to Radar Systems** by Dr. Robert O'Donnell, Massachusetts Institute of Technology. https://ocw.mit.edu/resources/res-ll-001-introduction-to-radar-systems-spring-2007	
31	**Mechatronics**	After successful completion of the course, student will be able to:		**SECTION A** **Mechatronics and its scope**: Basic Structure and Evolution	**Addition of new elective.**

		• Develop skills to monitor and control real world industrial systems • Implement projects for industrial and home automations • Analyze and create own innovative filters and signal conditioning applications • Perform computer based controlling of industries using PLC, SCADA and HMI		**Introduction of Transducer & Sensor:** Displacement, Pressure, Flow, Level and Temperature Measurements. Signal conditioning: amplification, filtering **PC based Control:** Smart Sensor, Data Acquisition System, PLC, SCADA, DCS and HMI System.	
				SECTION B **Pneumatic and Hydraulic actuation systems:** Directional control valves, Pressure control valves and Process control valves and cylinders. **Mechanical actuation system**- Kinematic chains, cams, gear-trains, Ratchet & Pawl, dampers, Bearings. **Electrical actuation system:** Mechanical switches- solenoid operated solid state switches, DC, AC & stepper motors. **Electrical Drives:** Conventional and Modern electrical drives, Classifications and Applications Closed loop Controllers: Performance Specifications, Delayed First and Second order system, PID Controller, ZN Tuning.	
				SECTION C **Case Studies of Mechatronics Systems:** Industrial Robot, Automobile Engine Control, Vehicle Suspension Control, MEMS, CNC Machine, Gyro system, 3-D Printer.	
				Recommended Books: 1. Isermann**,** Rolf (2005). *Mechatronics Systems*. Springer Publication 2. Bolton, W. (2003). *Mechatronics: electronic control systems in mechanical and electrical engineering*. Pearson Education. 3. Sawhney A.K. (2015). *A Course in Electrical and Electronic*	

				Measurements and Instrumentation. Dhanpat Rai & Co Publication 4. Nakra B.C. & Chaudhry K.K. (2013). *Instrumentation, Measurement and Analysis.* Tata McGraw Hill Publication	
32	**Fiber Optics and Communication**	After the completion of course student will be able to: • Explain the light propagation through optical fibers. • Explain the various light sources and optical detectors. • Design fiber optic transmitter and receiver system.	**Section A** **Fiber optics:** Introduction, optical fibers - geometrical Optics description, wave propagation, fiber modes, step index, graded index single and multimode fibers, dispersion, limitation on bit rate, fiber bandwidth, fiber loss, fiber manufacturing: design issue, fabrication methods, cables and connectors, fiber splicing and fiber couplers.	-----	**Move this course from 2nd semester to list of Elective** **No change in course contents.**
			Section B **Optical Sources and detectors:** Light-Emitting diodes: LED characteristics, modulation response, LED structures. Semiconductor Lasers: structures, Laser characteristics, single longitude mode operation, DFB and VCSEL laser, Receivers: photo detector design: P-N, PIN, Schottky barrier and Avalanche photodiode, Phototransistor, receiver noise: noise mechanisms in PIN and APD receivers, Receiver structures.	-----	
			Section C **Optical Fiber Systems:** optical transmitter circuit: source limitations, LED and Laser drive circuits, Optical receiver circuit, system design considerations, Digital systems, Digital optical receiver, BER, Optical power budgeting, rise time budget, line coding, analog systems: Direct intensity modulation, subcarrier intensity modulation, coherent systems, computer, sensor and military applications.	-----	

			Text Books: 1. Govind P. Agarwal: **Fiber-Optic Communication Systems:** Wiley India, 3rd Ed.2007. 2. John M. Senior: **Optical Fiber communication:** PHI. **References:** 1. D.C. Agrawal: **Fiber Optic Communication**: Wheeler Pub.2nd ed., 1993. 2. Gowar: **Optical Fiber Communication:** PHI, 1995. 3. Pallab Bhattacharya: **Semiconductor Optoelectronics Devices:** PHI 2nd ed., 2002. 4. Gerd Keiser: **Optical Fiber communication:** McGraw Hill, 2nd ed., 1991.	**Recommended Books:** 1. Agarwal, Govind. P. (2007). *Fiber-Optic Communication Systems***.** New Delhi: Wiley India. 2. Senior, John.M. (2009). *Optical Fiber Communication Principles & Practice***.** New Delhi: PHI Publication. 3. Bhattacharya, Pallab. (2002). *Semiconductor Optoelectronics Devices***.** New Delhi: PHI Publication. 4. Keiser, Gerd. (1991). *Optical Fiber Communication***.** New Delhi: McGraw Hill Publication.	
33	**Analytical Instrumentation**	After the completion of course student will be able to: • Explain majorly pH conductivity & dissolved component analyzer, dissolved oxygen analyzer, sodium analyzer, silica analyzer and moisture measurement. • Evaluate the performance of Spectrophotometers, FTIR Spectrometers and their applications. • Describe modern trends in NMR Spectrometers, X-ray Spectrometry, and Mass	----	**Section A** PH conductivity & dissolved component analyzer Sampling systems – ion selective electrodes – conductivity meters – pH meters - dissolved oxygen analyzer – sodium analyzer – silica analyzer – moisture measurement. GAS ANALYSER Oxygen analyzer – CO monitor, CO2, O2, dust and smoke measurement, thermal conductivity type– thermal analyzer–industrial analyzers.	**Addition of New Course as Elective**
			----	**Section B** Spectrophotometers: Spectral methods of analysis – Beer's law UV – visible spectrophotometers – single beam and double beam instruments – source and detectors – IR spectrophotometers – sources and detectors – FTIR spectrometers – atomic absorption spectrophotometer – flame emission	

		Spectrophotometers with their applications.		spectrophotometers – sources of flame photometry – applications.	
			-----	**Section C** Nuclear magnetic resolance and radiation techniques NMR – basic principle – NMR spectrometers – applications – introduction to mass spectrophotometers – nuclear radiation detectors – GM counter – proportional counter – solid state detectors, X-ray spectrometry: Instrumentation for X-ray spectrometry, X-ray diffractometer.	
			----	**Recommended Books:** 1. Willard., Merritt., Dean., & Settle. (2004). *Instrumental Methods of Analysis*. New Delhi: CBS Publishers & Distributors. 2. Ewing, Galen.W. (1985). *Instrumental Methods of Chemical Analysis*. New Delhi: McGraw-Hill Publication. 3. Liptak, B.G. (1995). *Process Measurement and Analysis*. Philadelphia: Chilton Book Company. 4. Settle,Frank.A. (1997). *Handbook of Instrumental Techniques for Analytical Chemistry*. New Delhi: PHI Publication. 5. Braun, Robert.D. (2012). *Introduction to Instrumental Analysis*. Hyderabad, Karnataka:BSP Books Pvt.Ltd. 6. Skoog., Holler.,&Crouch. (2017). Principles *of Instrumental Analysis*. New Delhi: Cengage Learning Publication. **Suggested e-resources:** **1. Modern Instrumental Methods of Analysis**by Prof. J. R. Mudakavi, Department of Chemical Engineering, Indian Institute of Science, Bangalore.	

				https://nptel.ac.in/courses/103108100/	
34	**Audio and Video Systems**	After the completion of course student will be able to: • Understand the fundamental concepts of television transmitter, receiver systems and the transmission of video signals and importance of television standards. • Understand different colour television systems used worldwide and its compatibility. • Principles of recording and reproduction of disc and video cassete recorders.	----	**Section A** **Audio Systems:** Types of microphones and speakers, Monophonic, stereophonic and quadraphonic audio systems. **Disc and Magnetic Recording and Reproduction :** Monophonic and stereophonic disc recording and reproducing systems, Magnetic recording , playback, Biasing & equalization, Recording medium, Magnetic heads-replay & eraser heads, Audio cassettes, Tape speed, Maximum usable frequency, Tape transport mechanism, Distortion & noise aspects, Hi-Fi stereo system.	**Addition of New Course as Elective**
			-----	**Section B** **Video Cassette Recorders:** Video recording requirements, Video tape formats. Modulation-up conversion and down conversion of video signal, Servo systems, Functional Block diagram of VCR: video recording & playback. **Compact Disc Recording and Reproduction:** advantages of Compact disc, & its Specifications, CD player, optical recording, CD technology & manufacturing, CDROM, CD video.	
			----	**Section C** **Video Cameras:** Image conversion principle, Plumbicon, Sidicon camera tubes, three tubes colored camera, Block diagram of color camera tube. **TV Engineering:** Scanning process, Interlaced scanning, Composite video signals, Principle of black & white TV, color TV, Primary colours, Chrominance & luminance signals.	
			----	**Recommended Books:**	

				1. Bali, S.P.,&Bali, R. (2014). *Audio Video Systems Principles, Practices, and Troubleshooting***.** New Delhi: Khanna Book Publishing Co. 2. Sharma, Ajay. (1998). Audio *and Video Systems***.** New Delhi: Dhanpat Rai & Co. 3. Gupta, R.G. (2010). *Audio and Video Systems: Principles, Maintenance and Troubleshooting***.** New Delhi: Tata Mc-Graw Hill **Suggested e-resources:** 1. **Digital Video Signal Processing** by Prof.Sumana Gupta, Department of Electrical Engineering, IIT Kanpur. https://nptel.ac.in/courses/117104020/1 2. **Audio System Engineering** by Prof.Shyamal Kumar Das Mandal, Department of Electronics and Communication Engineering, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105133/22	
35	**Digital Signal Processing**	After the completion of course student will be able to: • Students will be familiar with the most important methods in DSP. • Students will be familiar with design and functioning of digital filter design • Student will be able to transform-domain processing.	**Section A** Introduction of Signals, Systems and Signal Processing, Classification of Signals and Systems, Advantages of digital over analog Signal processing, Signal Models - Continuous Time versus Discrete time signals, Periodic and aperiodic Signals, Phasor Signals and Spectra, Energy and Power Signals, System Modeling Concepts, The superposition integral for Fixed and Linear Systems, Impulse Response of a Fixed and Linear System - Fourier Series - Trigonometric Series- Exponential Fourier Series-Symmetry Properties of the Fourier Coefficients. Fourier Integral, Energy Spectral Density, Fourier Transforms in	----	**Move this course from 2nd semester to list of Elective** **No change in course contents.**

			the Limit, Fourier Transform Theorems and Pairs, System Analysis with Fourier Transform, Lap lace Transform Theorems, Network Analysis using the Lap lace Transform.		
			Section B Discrete Time Signals and Systems - Review of Sampled Data Systems, Time Domain Representations of Discrete Time Signals, Frequency Domain Representation of Discrete Time Signals, Discrete Time Signals obtained by sampling, Discrete Fourier Transform. Z-Transform - Definition and Examples, Inverse Z-Transform, Properties of the Z-Transform, Introduction to Realization of Digital Systems - Block Diagrams and Signal Flow Graphs. Introduction to Realization of an IIR and FIR systems, Discrete Fourier Transforms (DFT) and Fast Fourier Transform (FFT).	----	
			Section C Design of Digital Filters: Introduction to Filters, A comparison of IIR and FIR Digital Filters. Design of IIR Digital Filters –Impulse Invariant Transformation, Bilinear Transformation, Design of Digital Butter worth and Chebyshev Filters. Design of FIR Digital Filters - Windowing and Rectangular Window, Filter Designs using Windows, Frequency Sampling Technique. DSP tools and DSP techniques in various applications.		
			Text Books: 1. Johnson Johnny R.: **Introduction to Signal Processin:** Prentice-Hall of India, 1998. 2. Oppenheim V. Alan: **Signal & Systems:** Prentice-Hall of India, 1995.	**Recommended Books:** 1. Johnson, Johnny. R. (1998). **Introduction to Signal Processing**. New Delhi: phi Publication. 2. Oppenheim, V. Alan. (1995). **Signal & Systems**. New Delhi: PHI Publication.	

			3. ProakisG.John: **Digital Signal Processing:** Prentice-Hall of India, 3rd edition, 2002.	3. Proakis, G.John. (2002). **Digital Signal Processing.** New Delhi: PHI Publication. **Suggested E-resource**: **1.** Digital Signal Processing by Prof: S. C. Dutta Roy, Department of Electrical Engineering Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/117102060/	
36	**Geoinformatics**	After the completion of course student will be able to: • Describe spatial database, Co-ordinate and projection system • Analyse vector and raster based analysis in Geographical Information Sciences • Describe different types of satellite system and digital image processing	----	**Section A** Geographical Information System: Definition, Components of GIS, Hardware and software requirements for GIS, Coordinate system and projections, Database structure and formats, Spatial data models - raster and vector. Data inputting, Data base design - editing and topology creation. Linkage between spatial and Non spatial data, Query (Attribute/Spatial), Vector based analysis. Raster based analysis. Errors, Digital Elevation Model, Network analysis, Open source and WebGIS.	**Addition of New Course as Elective**
			-----	**Section B** Remote Sensing: Definition - components of remote sensing - energy sensor, interacting body; Type - active and passive remote sensing. Satellite System - meteorological, communication and remote sensing. Platforms - aerial and space, synoptivity and repeativity. Electromagnetic Radiation (EMR) - EMR spectrum- visible, infrared [IR) middle IR, thermal IR and microwave. EMR interaction with earth surface material, radiance, irradiance, incident, reflected, absorbed and transmitted energy, spectral	

				response pattern - spectral signature curves (water, soil and vegetation]. Digital Image Processing: Digital Image, Satellite Image - characteristics and formats. Resolution - spatial, spectral, radiometric and temporal; Introduction to rectification, enhancement; Classification - Unsupervised and Supervised classification.	
			----	**Section C** Global Positioning System: Global Navigation Satellite System (GNSS), GPS, GLONASS, GALILEO, Segments - space, control, user, GPS Satellite signals, sources of errors and corrections. Applications of Remote Sensing and GIS: Applications of GIS and Remote Sensing in resource management (forestry, agriculture, urban telecommunication, transportation, water resources and environment).	
			-----	**Recommended Books:** 1. Chor, Pang. Lo.,&Albert, K. W. Yeung (2006). *Concepts and Techniques-of Geographic Information Systems*. New Delhi: PHI Publication. 2. Heywood, D.I., Cornelius, S. & Carver, S. (2009). *An Introduction to Geographical Information Systems*. New Delhi: Pearson Publication. 3. Joseph, G. (2005). *Fundamentals of remote sensing*. Jaipur, Rajasthan: Universities Press. 4. Jensen, John. R. (2015). *Introductory Digital Image Processing: A Remote Sensing Perspective*. New Delhi: Pearson Publication. 5. Sabins, Floyd F. (2007). *Remote Sensing: Principles and Interpretation*.	

				Long Grove, Illinois: Waveland Press **Suggested e-resources:** 1. **Geoinformatics** by University of Twente. https://www.itc.nl/ilwis/applications-guide/ 2. **Geographical Information System** by Dr A. K. Gosain, Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/105102015/1	
37	**Power Electronics**	After the completion of course student will be able to: • To explain various power semiconductor devices like Thyristor, GTO, MOSFET and IGBT • Analyze the various rectifiers used in power circuits and DC to DC Converters • Explain the inverter operation and how harmonics are reduced and explain the basic working principle of cyclo-converters	----	**Section A** Need of power electronics, Introduction to power electronics devices (static and dynamic characteristics) power diodes, power transistor, power MOSFETS, IGBT, MCT, GTOs, Triac. Thyristor SCR: Operational characteristics, Turn ON methods, switching characteristics, thyristor protection, over voltage protection, over current protection, gate protection, snubber circuit Firing circuits for Thyristors, heating, series and parallel combination of Thyristors.	**Addition of New Course as Elective**
			----	**Section B** Commutation Techniques: Load commutation, resonant- pulse commutation, complementary commutation, impulse commutation, line commutation, Phase controlled rectifier: Principal of phase control, single and three phase converters. Effect of source impedance on the performance of converters, dual converter (ideal and practical) DC choppers: Principle, control strategies, step-up and step-down choppers.	
			----	**Section C** Inverters: Single-phase voltage source inverters 180 and 120 mode operation; Fourier analysis of single-phase inverter	

				output voltage. Pulse width modulated inverters, Reduction of harmonics in the inverter output, single-phase current source inverters with ideal switch. Cyclo-converters: Step-up and step-down cyclo-converter, Single phase to single-phase cyclo-converters three-phase half wave cyclo-converters.	
			----	**Recommended Books:** 1. Rashid, Mohammad. H. (2017). *Power Electronics Circuits, Devices and Applications*: New Delhi: PHI Publication. 2. Bimbhra, P.S. (2012). *Power Electronics***:** New Delhi: Khanna Publication. 3. Moorthy, Rama, (1991). *An Introduction ToThyristors and Their Application***:** New Delhi: Affiliated East-West Press. **Suggested E-Resources:** 1. **Power Electronics** by Prof.B.G. Fernandes, Department of Electrical Engineering, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101038/ 2. **Power Electronics** by Prof. D. Prasad, Dr. D. Kastha, Prof.Sabyasachi Sengupta, Prof. N. K. De, Dept of Electrical Engineering, IIT Kharagpur. https://nptel.ac.in/courses/108105066/	
38	**Robotics and Automation**	After completion of this course, students will be able to: • Develop skills of creating industrial and mobile robot projects • Implement robots like KUKA, PUMA in real industrial world	----	**SECTION A** **BASIC CONCEPTS-** Automation and Robotics – An over view of Robotics – present and future applications – classification by coordinate system and control system, Dynamic stabilization of Robotics. **POWER SOURCES AND SENSORS-** Hydraulic, Pneumatic and electric drivers	**Addition of New Course as Elective**

		• Create innovative robot designs using mathematical concepts of kinematics • Develop autonomous mobile robots in surveillance, security, home and office services		– Determination HP of motor and gearing ratio, variable speed arrangements, Path Determination - Machinery Vision – Ranging – Laser – Acoustic, Magnetic Fiber Optic and Tactile Sensor.	
			-----	**SECTION B** **MANIPULATORS-** Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and Pneumatic manipulators. **ACTUATORS AND GRIPPERS-** Pneumatic, Hydraulic Actuators, Stepper Motor Control Circuits, End Effecter, Various types of Grippers, Design consideration. Differential transformation and manipulators, Jacobians – problems .Dynamics: Lagrange – Euler and Newton – Euler formations – Problems.	
			----	**SECTION C** **KINEMATICS-** Forward and Inverse Kinematic Problems, Solutions of Inverse Kinematic problems, Multiple Solution, Jacobian Work Envelop – Hill Climbing Techniques. **PATH PLANNING-** Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion – straight line motion – Robot programming, languages and software packages. **CASE STUDY-** Multiple Robots – Machine Interface – Robots in Manufacturing and Non-Manufacturing applications – Robot Cell Design Selection of a Robot.	
			------	**Recommended Books:** 1. Groover, M. P., Weiss, M., Nagel, R. N., & Odrey, N. G. (2017). *Industrial Robotics: Technology, programming,*	

				and Applications (2/e). McGraw-Hill Education Publication 2. Niku, S. (2010). *Introduction to robotics*. John Wiley & Sons. 3. Fu, K. S., Gonzalez, R., & Lee, C. G. (1987). *Robotics: Control Sensing. Vis.* Tata McGraw-Hill Education. 4. Mittal, R. K., & Nagrath, I. J. (2003). *Robotics and control*. Tata McGraw-Hill. 5. Craig, J. J. (2009). *Introduction to robotics: mechanics and control, 3/E*. Pearson Education India. 6. Spong, M. W., & Vidyasagar, M. (2008). *Robot dynamics and control*. John Wiley & Sons. **7.** Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2010). *Robotics: modelling, planning and control*. Springer Science & Business Media.	
39	**Antenna Analysis**	After the completion of course student will be able to: • Recall electromagnetic plane waves. Apply principles of electromagnetic to explain antenna radiation. Explain various antenna parameters. • Explain antenna as a point source. Design antenna patterns for different cases. • Explain dipole antennas. Establish mathematical equations for various parameters of thin linear	----	**Section A** Introduction to antenna, Radiation Mechanism,Current Distribution on a Thin Wire Antenna Fundamental parameters of antenna: Radiation pattern, Radiation power density, Radiation intensity, Beamwidth, Directivity,Antenna efficiency, Gain, Beam efficiency, Bandwidth, Polarization, Input impedance, Antenna radiation efficiency, Antenna vector effective length, Maximum directivity and Maximum effective area, Friss transmission equation and radar range equation	**Addition of New Course as Elective**
			----	**Section B** Radiation Integrals and Auxiliary Potential Functions: The Vector Potential A for an Electric Current Source J, The Vector Potential F for a Magnetic Current Source	

		antenna.		M, Electric and Magnetic Fields for Electric (J) and Magnetic (M) Current Sources, Solution of the Inhomogeneous Vector Potential Wave Equation, Far-field radiation, Duality theorem, Reciprocity and Reaction theorem, Image Theory Linear wire antennas: Infinitesimal dipole, Small dipole, Region separation, Finite length dipole, Half-wave dipole Loop Antennas: Small circular loop, Square loop	
			-----	**Section C** Introduction to Arrays, two-element array, N-element linear array: uniform amplitude and spacing, directivity,N-element linear array: uniform spacing, non-uniform amplitude Traveling wave antennas: Long wire antenna, V-antenna, Rhombic antenna Broadband antennas: Helical antenna, Folded dipole, Yagi-uda array of linear elements Log-periodic antenna, Introduction to Horn antenna: E-plane sectoral horn, H-plane sectoral horn, Pyramidal horn	
			-----	**Recommended Books:** 1. Balanis, C. A. (2005). *Antenna Theory Analysis and Design.* New Delhi: John Wiley & Sons. 2. Eliott, Robert S. (2003). *Antenna Theory and Design*. New Delhi: Wiley-IEEE Press. 3. Kraus, J. D., &Marhefka, R. H. (2001). *Antennas for All Applications*, Singapore: McGraw-Hill Publication. 4. Harrington, R. F. (2001). *Time-Harmonic Electromagnetic Fields*. New Delhi: Wiley-IEEE Press. **Suggested E- resources:** 1. **Advanced Antenna Theory** by Dr	

				Amalendu Patnaik, Indian Institute of Technology, Roorkee. https://nptel.ac.in/courses/117107035/ 2. **Analysis and Design Principles of Microwave Antennas** by Prof.Amitabha Bhattacharya, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105114/ **3. Antennas** by Prof. Girish Kumar, Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/108101092/	
40	**Communication Networks**	After the completion of course student will be able to: • Recognize and describe about the working of Computer Networks. • Illustrate reference models with layers, protocols and interfaces. • Summarize functionalities of different Layers.	**Section A** Introduction to communication systems and data communications. Introduction of network, requirement of Internet. Data Networking, Network history, Local area network topologies, WAN, MAN, VPN, (Virtual Private Network). Bandwidth, Bandwidth data rate. Multiplexing-TDM, FDM, CDMA, data encoding. Network model-layer structure of network model. OSI Model, OSI layers. TCP/IP Model layers. Arpanet, Peer to Peer communication. Communication Media and cable-structure-through wire-copper cable-STP, UTP, co-axial cable, optical fiber. Wireless media-wireless LAN, organization and standards. Wireless devices and topologies. Wireless communication, wireless security.	----	**Move this course from 3rd semester to list of Elective** **No change in course contents.**
			Section B Network layer devices-Modem, NIC, hub, bridge, switch, router, firewall, gateway. Switching Networks-circuit switching, Packet Switching. Networks-Circuit Switching, Packet Switching. Networks addressing schemes-MAC Address, Subneting, Superneting. Routing Concept, Routing protocol (RIP), Routed protocols. Introduction to IPV6 Principles of	-----	

			Internetworking. Ethernet (CSMA/CD) Token Ring and FDDI, Fast Ethernet.		
			Section C Layer protocol Structure. Data link control – Flow Control, Error Detection, Error Control. HDLC. Network layer-ARP, RARP, ICMP. Effect of Congestion and Congestion Control in Network-(Back pressure, choke packet, Implicit Congestion Signaling, Explicit Congestion Signaling. Traffic Management-Transport layer Protocols-connection oriented and connectionless services, TCP, TCP Congestion Control and Flow Control. UDP. Application Layer Protocols – HTTP, FTP, SMTP, SNMP, Telnet. Introduction to ISDN. Narrow Band and Broad Band. Introduction to WAN Technologies. ATM and Frame relay.	----	
			Text Books: 1. E.C. Jordan: **Electromagnetic wave & Radiating System:** PHI, II edition 1986. 2. A.S. Tannanbaum: **Computer Networks:** Pearson Education 2003. 3. W.Stailling: **Data & Computer Communication**: PHI New Delhi, 5th edition 1997. 4. J. Martin: **Computer Networks and Distributed Processing**: PHI, 1998.	**Recommended Books:** 1. Jordan, E.C.(1986). *Electromagnetic Wave & Radiating System*. New Delhi: PHI Publication. 2. Tanenbaum, A.S. (1997). *Computer Networks*. New Delhi: Pearson Publication. 4. Stailling, W. (1997). *Data & Computer Communication*. New Delhi: PHI Publication. 5. Martin, J. (1998). *Computer Networks and Distributed Processing Software, Techniques, Architecture*. New Delhi: PHI Publication. **Suggested E-Resources:** 1. **Computer Networks and Internet Protocol** by Prof.SoumyaKanti Ghosh Department of Computer Science and Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/106105183/ 2. **Computer Networks** by Prof. Sujoy	

				Ghosh, Department of Computer Science and Technology, IIT KG. https://nptel.ac.in/courses/106105081/ 3. **Computer Networks** by Prof. Hema A Murthy, IIT Madras. https://nptel.ac.in/courses/106106091/ 4. **Data Communication** by Prof.Ajit Pal, IIT KG. https://freevideolectures.com/course/2278/data-communication	
41	**Professional Ethics**	----	-----	The course is intended to provide participants with the ability to analyze ethical situations, such as how they interact and what can be expected from them as correct ethical behaviour. In turn, any professional will benefit from a critical scrutiny of their own ethics by those from other professions. The general principles of professional ethics will be examined, as well as the distinctive problems of the different fields. The participant will also be expected to explain the pertaining issues, such as professional codes of ethics, confidentiality, obligations and Moral Values in Professional Ethics, the limits of predictability and responsibilities of the engineering profession, research misconduct, and work place rights & responsibilities. **Suggested e-resources:** 1. **Professional Ethics** by Rochester Institute of Technology. http://www.openculture.com/professional-ethics-a-free-online-course. 2. **Ethical Practice: Leading Through Professionalism, Social Responsibility, and System Design** by Prof. Leigh Hafrey, MIT, USA. https://ocw.mit.edu/courses/sloan-	**Addition of New Course as Reading Elective**

				school-of-management/15-270-ethical-practice-leading-through-professionalism-social-responsibility-and-system-design-spring-2016.	
42	**IoT Sensors and Devices**	----	----	This course is for practical learners who want to explore and interact with the IoT bridge between the cyber- and physical world. Student will learn about the 'things' that get connected in the Internet of Things to sense and interact with the real world environment – from something as simple as a smoke detector to a robotic arm in manufacturing. This course is about the devices that feel and the devices that respond. The course also describe about IoT sensors, actuators and intermediary devices that connect things to the internet, as well as electronics and systems, both of which underpin how the Internet of Things works and what it is designed to do. **Suggested e-resources:** 1. **IoT Sensors and Devices** by Curtin University. https://www.edx.org/course/sensors-and-devices-in-the-iot. 2. **Internet of Things: Sensing and Actuation** by University of California San Diego https://www.coursera.org/learn/internet-of-things-sensing-actuation.	**Addition of New Course as Reading Elective**
43	**Electromagnetic Compatibility**	----	----	This course describe the systems that generate or consume electrical energy can produce electromagnetic noise that may interfere with the operation of the system itself and/or other systems. The course will enable students to understand how the principles of electricity and magnetism can be applied to design electrical and electronic systems that can co-exist	**Addition of New Course as Reading Elective**

				harmoniously, that is, to design systems that are electromagnetically compatible with each other. The students will also be expected to explain how electromagnetic disturbances are generated in systems, how they couple to other systems, and how systems can be protected. **Suggested e-resource:** 1. **Electromagnetic Compatibility** by Daniel Mansson, KTH Royal Institute of Technology, Sweden https://onlinecourses.nptel.ac.in/noc19_ee17/preview.	
44	**Electric Vehicles**	**----**	**-----**	Electric vehicles are the future of transportation. Electric mobility has become an essential part of the energy transition, and will imply significant changes for vehicle manufacturers, governments, companies and individuals. This course prepare the students for product development positions in the automotive, communications, solar, wind turbine, and smart grid industries and service positions in the automotive industry. This course will be a first level course on electric vehicle. Students will be able to understand the operation of battery driven electric vehicle. The course will focus on areas that come under the umbrella of electric vehicles, such as vehicle dynamics, Motors, Power Electronics, Batteries, Charging and etc. Students will explore the most important aspects of this new market, including state-of-the-art technology of electric vehicles and charging infrastructure **Suggested e-resources:** 1. **Electric Vehicles Part 1** by IIT Delhi. https://onlinecourses.nptel.ac.in/noc19_	**Addition of New Course as Reading Elective**

				ee18/preview. 2. **Electric Cars: Introduction** by Delft University of Technology (TU Delft). https://www.edx.org/course/electric-cars-introduction-0.	
45	**Electronic Packaging**	----	----	This course is designed to provide a basic knowledge of the technologies and processes required for the packaging of electronic products. The focus of the course will be on the mechanical, and materials aspects which are often neglected in the design phase with potentially catastrophic consequences. Students will be expected to explore the underlying scientific and technological knowledge-based needed to become proficient builders and users of electronic systems. The students will also be able to explain the fundamental principles for packaging active and passive electronic devices; design of components, circuit boards, connectors, and assemblies; electromagnetic interference and its impact on packaging, thermal and mechanical design; and reliability assessment methods. **Suggested e-resource:** 1. **Electronics Packaging and Manufacturing** by IIT Kharagpur https://onlinecourses.nptel.ac.in/noc18_me54.	**Addition of New Course as Reading Elective**
46	**Multimedia Compression and Communication**	-----	-----	The purpose of this course is to understand the multimedia communication and compression. In this course students will be expected to explore various multimedia components and their characteristics, such as hardware, animation and graphics and able to explain the various audio and video compression techniques and apply these techniques in multimedia communication.	**Addition of New Course as Reading Elective**

				The student will also be able to develop the understanding of network architecture, protocols, resource management, multimedia operating systems, scheduling and policing mechanisms. **Suggested e-resource:** **1. Multimedia Processing** by IIT Kharagpur. https://nptel.ac.in/syllabus/117105083/.	
47	**Telecommunication switching systems and networks**	-----	-----	The course is intended to develop the good understanding of the fundamentals and application of telecommunication networks i.e. PSTN, PDN and ISDN, modern digital telecommunication switching and networks. The participants will be expected to explain the recent terminology, like switching systems, traffic management, time division switching systems, data communication Networks, routing, ISDN, voice data integration and importance of telephone traffic analysis and telephone networks. **Suggested e-resources:** 1. **Computer Networks** by Department of CSE, IIT Kharagpur https://nptel.ac.in/courses/Webcourse contents/IIT%20Kharagpur/Communication%20network/New_index1.html. **2. Data Communication** by IIT Kharagpur. https://nptel.ac.in/courses/106105082/19.	**Addition of New Course as Reading Elective**
48	**ELE 205, Semiconductor Devices and Circuits**	After completion of this course, students will be able to: • Explain the energy bands, temperature effects, carrier transport of semiconductor devices		**Section A** P-N junction: thermal equilibrium condition, under forward and reverse bias, space charge region, junction capacitance, p-n junction current, small signal model, diode current equation, junction breakdown, charge storage and transient behavior, metal semiconductor junction:	

		• Explain the switching times, capacitance of PN junction, bipolar and unipolar transistor behavior and their differences • Analyze the various feedback circuits and design power amplifiers.		Schottky Barriers and Ohmic Contacts, heterojuntion: energy band diagrams	
				Section B Bipolar Junction Transistor: the transistor action, minority carrier distribution, low frequency common-base current gain, MOSFET: The MOS diode, Energy band diagrams, MOSFET fundamentals, MOS Transistor current, Threshold Voltage. FET biasing: fixed-Bias configuration, self-Bias configuration, Voltage-divider Bias configuration, FET small signal model, common source and common drain amplifiers.	
				Section C Feedback amplifier: classifications of amplifiers, general feedback structure, properties of negative feedback, feedback topologies, Transfer gain with feedback, General Characteristics of negative feedback amplifiers, Input resistance, output resistance, Voltage series and current series feedback, Current shunt and voltage shunt feedback, Power amplifiers: Classification, operation, Analysis and design of Class A, Class B, Class-AB, Class C, Power dissipation and efficiency calculations, amplifier distortion.	
				Recommended Books: 1. S. Simon. M.(2002), *Semiconductor Devices Physics and Technology (2/e)* , New Jersey, USA: JOHN WILEY & SONS Publication 2. Millman. J, Halkias. C, Parikh. C. (2017). *Integrated Electronics. (2nd ed).* New Delhi: TMH Publications. 3. Streetman Ben. G. (2006). *Solid State Electronic Devices (6th ed)* New Delhi: PHI Publications.	

				4. Smith. S.(2008). *Microelectronics Circuits. (5th ed).* New Delhi: Oxford press. **Suggested E-Resources:** 1. **Semiconductor Devices and Circuits** by Prof.SanjivSambandan, Department of Instrumentation and Applied Physics, Indian Institute of Science, Bangalore. https://nptel.ac.in/courses/108108112/ 2. **Analog Electronic Circuits** byProf. S. C. Dutta Roy, Department of Electrical Engineering Indian Institute of Technology Delhi. https://nptel.ac.in/courses/108102095/	

Annexure IV

Name of Programme: Master of Technology (VLSI Design)

Programme Educational Objectives: The M.Tech. (VLSI Design) programme aims for the holistic development of students through the unique and innovative fivefold educational ideology of Banasthali Vidyapith. State-of-the-art VLSI technology requires research in physical devices as well as novel design and development of integrated circuits.The M. Tech. (VLSI Design) programme at Department of Electronics aims to impart knowledge of VLSI system design covering algorithms, hardware description languages, system architectures, physical designs, verification techniques, simulation & synthesis, low power design techniques and etc.The programme offersfoundational subjects like semiconductor devices, digital, analog and RFIC design, embedded system, electronic system packaging etc. Many courses have prominent lab component, offering hands-on training and exercises on numerous practical aspects of crucial importance. The students also get an opportunity to participate in projects related to design and optimization of VLSI circuits and systems.

The main objectives of M.Tech. (VLSI Design) programme are:

- To provide in-depth knowledge of device fundamentals and modern circuits design to gain an ability to analyze, design, and implement VLSI Systems circuits and systems.
- To enrich students to excel in research leading to cutting edge technology in VLSI design to create competent, innovative and productive professionals.
- To train them to understand the various recent issues and find the solutions with good scientific and engineering knowledge, so as to comprehend, analyze, design, and create novel products and develop the capability to prepare the scientist report in lucid and articulate form.
- To provide students with an academic environment to develop scientific awareness, leadership, ethical conduct, positive attitude, societal responsibilities and the lifelong learning needed for a successful professional career.
- To develop entrepreneurial skills in starting industries using VLSI technology.
- Practice the ethics of their profession and inculcate a lifelong learning culture.
- Communicate effectively and manage resources skilfully as members and leaders of the profession.

Programme Outcomes:

PO1. **Scholarship of Knowledge:** Acquire in-depth knowledge of VLSI technology in wider and global perspective, with an ability to discriminate, evaluate, analyze, synthesize and integrate for enhancement of knowledge. Graduates will be able to apply the knowledge of computing, mathematics, science and electronic engineering for designing VLSI circuits.

PO2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using basic principles of mathematics, science and engineering.

PO3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations. Graduates will have an ability to design and conduct experiments, perform analysis and interpret the problems of VLSI design.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern VLSI tools including modeling to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Engineering Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Leadership Skills:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments.

PO12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Scheme:

M.Tech. (VLSI Design) Semester - I (December, 2019)

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
VLSI 507	Digital CMOS IC design	4	0	0	4	VLSI 507	Digital CMOS IC design	4	0	0	4
VLSI 507L	Digital CMOS IC design Lab	0	0	2	1	VLSI 507L	Digital CMOS IC design Lab	0	0	2	1
VLSI 512	HDL Based System Design	4	0	0	4	VLSI 512	HDL Based System Design	4	0	0	4
VLSI 512L	HDL Based System Design Lab	0	0	6	3	VLSI 512L	HDL Based System Design Lab	0	0	6	3
VLSI 516	IC Fabrication Technology	4	0	0	4	VLSI 516	IC Fabrication Technology	4	0	0	4
VLSI 516L	IC Fabrication Technology Lab	0	0	2	1	VLSI 516L	IC Fabrication Technology Lab	0	0	2	1
VLSI 521P	Minor Project (Part - I)	0	0	2	1	VLSI 521P	Minor Project (Part - I)	0	0	2	1
VLSI 525	Solid States Device Modeling and Simulation	4	0	0	4	VLSI 525	Solid States Device Modeling and Simulation	4	0	0	4
	Elective-I	4	0	0	4		Discipline Elective	4	0	0	4
Semester wise total		20	0	12	26	**Semester wise total**		20	0	12	26

M.Tech. (VLSI Design) Semester - II (April/May, 2020)

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
VLSI 503	Analog and Mixed Signal IC Design	4	0	0	4	VLSI 503	Analog and Mixed Signal IC Design	4	0	0	4
VLSI 503L	Analog and Mixed Signal IC Design Lab	0	0	4	2	VLSI 503L	Analog and Mixed Signal IC Design Lab	0	0	4	2
VLSI 504	ASIC Design	4	0	0	4	VLSI 504	ASIC Design	4	0	0	4
VLSI 505	CAD for IC Design	4	0	0	4	VLSI 505	CAD for IC Design	4	0	0	4
VLSI 505L	CAD for IC Design Lab	0	0	4	2	VLSI 505L	CAD for IC Design Lab	0	0	4	2
VLSI 522P	Minor Project (Part - II)	0	0	4	2	VLSI 522P	Minor Project (Part - II)	0	0	4	2
VLSI 524	RF IC Design	4	0	0	4	VLSI 524	RF IC Design	4	0	0	4
	Elective - II	4	0	0	4		Open Elective	4	0	0	4
	Semester wise total	20	0	12	26		**Semester wise total**	20	0	12	26

List of Discipline Electives:

Course Code	Course Name	L	T	P	C
CS 429	Pattern Recognition and Image Processing	**4**	**0**	**0**	**4**
CS 431	Real Time Systems	**4**	**0**	**0**	**4**
ELE 502	Discrete Time Signal Processing	**4**	**0**	**0**	**4**
VLSI 501	Advanced Digital Signal Processing	**4**	**0**	**0**	**4**
VLSI 502	Advanced Digital System Design	**4**	**0**	**0**	**4**
VLSI 506	Design of Semiconductor Memory	**4**	**0**	**0**	**4**
VLSI 510	Embedded System Design	**4**	**0**	**0**	**4**
VLSI 511	Fault Tolerance in VLSI	**4**	**0**	**0**	**4**
VLSI 513	High Level System Design and Modeling	**4**	**0**	**0**	**4**
VLSI 514	High Power Semiconductor Devices	**4**	**0**	**0**	**4**
VLSI 515	High Speed VLSI Design	**4**	**0**	**0**	**4**
VLSI 517	Integrated Electronic System Design	**4**	**0**	**0**	**4**
VLSI 518	Introduction to MEMS	**4**	**0**	**0**	**4**
VLSI 519	Low Power VLSI Design	**4**	**0**	**0**	**4**
VLSI 520	Nanoelectronics	**4**	**0**	**0**	**4**
VLSI 523	Representation and Analysis of Random Signals	**4**	**0**	**0**	**4**
VLSI 526	Speech Signal Processing	**4**	**0**	**0**	**4**
	Photonics Integrated Circuits	**4**	**0**	**0**	**4**

M.Tech. (VLSI Design) Semester - III (December, 2020)

Existing Scheme						**Proposed Scheme**					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Reading Elective - I	0	0	4	2		Reading Elective - I	0	0	0	2
VLSI 602P	Project (Part - I)	0	0	48	24	VLSI 602P	Project (Part - I)	0	0	48	24
	Semester wise Total	0	0	52	26		**Semester wise Total**	0	0	48	26

M.Tech. (VLSI Design) Semester - IV (April/May, 2021)

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Reading Elective - II	0	0	4	2		Reading Elective - II	0	0	0	2
VLSI 603P	Project (Part - II)	0	0	48	24	VLSI 603P	Project (Part - II)	0	0	48	24
Semester wise total		0	0	52	26	**Semester wise total**		0	0	48	26

*** L - Lecture hrs/week; T - Tutorial hrs/week;**
P - Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C - Credit Points of the Course

Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters I, & II with prior permission of respective heads, time table permitting.

List of Reading Electives:

S. No.	Course Code	Reading Elective
1.	VLSI 601R	High Level Synthesis
2.		Advanced Electronics Packaging
3.		Digital Image Processing
4.	VLSI 604R	VLSI Testing and Design for Testability
5.		Compound Semiconductor Technology
6.		Organic Electronic Devices

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
1.	**VLSI 507, Digital CMOS IC Design**	After completion of this course, students will be able to: • Gain in-depth understanding of designing and analysis of CMOS inverters • Explain the fabrication process and layout design of CMOS digital IC • To describe the operation of semiconductor memories and low power circuits.	—	—	**No Change in course contents.**
			Text Books: 1. N. H. E. Weste and K. Eshraghian, Principles of CMOS VLSI Design, Addison-Wesley Publishing Co., 2nd Edition, 1993. 2. Nell H. E. Weste and Kamran Eshraghian, "Principles of CMOS VLSI Design", 2nd Edition, Addision Wesley,1998. 3. Jacob Backer, Harry W. Li and David E. Boyce, " CMOS Circuit Design, Layout and Simulation ", Prentice Hall of India, 1999 4. Sung-Mo Kang, Yusuf Leblebici,, "CMOS Digital Integrated Circuits" - Analysis and design, Tata McGraw-Hill - third edition. 5. Douglas a. Pucknell and K.Eshragian., "Basic VLSI Design" 3rd Edition. PHI, 2000.	**Recommended Books:** 1. Weste, Neil. H. E.,& Eshraghian, K. (1993). *Principles of CMOS VLSI Design.*Boston, New York: Addison Wesley Publication. 2. Weste, Neil. H. E., & Eshraghian, K. (1998). *Principles of CMOS VLSI Design.*Boston, New York: Addison Wesley Publication. 3. Backer, Jacob., Harry, W. Li., & Boyce, David. E. (1999). *CMOS Circuit Design, Layout and Simulation.*New Delhi: PHI Publication. 4. Kang, Sung-Mo., & Leblebici, Yusuf. (2002). *CMOS Digital Integrated Circuits- Analysis and design*. New Delhi: Tata McGraw-Hill Publication. 5. Pucknell, Douglas. A.,& Eshragian, K.(2000). *Basic VLSI Design*. New Delhi: PHI Publication. **Suggested E-resources:** 1. **Computation Structures - Part 1: Digital Circuits** by Chris Terman https://www.edx.org/course/computation-structures-part-1-digital-mitx-6-004-1x-0 2. **CMOS Digital VLSI Design** by Prof. S. Dasgupta https://onlinecourses.nptel.ac.in/noc19_ee25/preview	

2.	**VLSI 507L, Digital CMOS IC Design Lab**	After completion of this laboratory course, students will be able to: • Understand of Cadence circuit design tool • Understand procedure to analyse DC and Transient behaviour of circuits • Understand procedure to analyse effects of device dimension variation on circuit performance	------	-------	**Learning Outcomes added.** **No change in Experiment List**
3.	**VLSI 512, HDL Based System Design**	After completion of this course, students will be able to: • Analysis and Design of Synchronous and Asynchronous sequential machines • Draw a FSM chart for digital designs and describe it using HDL. • Detect and diagnosis different errors in digital circuit descriptions. • Design the digital systems through VHDL and Verilog HDL.	—	—	**No Change in course contents.**
			Text and Reference Books: 1. Z. Navabi, VHDL: Analysis and Modeling of Digital Systems, McGraw Hill. 2. J. Bhaskar, A VHDL Primer, Prentice Hall. 3. R. Lipsett, C. Schaefer and C. Ussery, VHDL: Hardware Description and Design, Kluwer. 4. J. Pick, VHDL: Techniques, Experiments and Coveats, McGraw Hill. 5. D. E. Ott and J. J. Wilderotter, Designer's Guide to VHDL Synthesis, Kluwer. 6. S. Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Prentice Hall NJ, USA), 1996. 7. ~~J. Bhaskar, "Verilog HDL Synthesis - A Practical Primer", Star Galaxy~~	**Recommended Books:** 1. Navabi, Z. (1997) *VHDL: Analysis and Modelling of Digital Systems*. New Delhi: McGraw Hill Publication. 2. Bhaskar, J. (2015). *A VHDL Primer*. New Delhi: Pearson Publication. 3. Lipsett, R., Schaefer, C.,&Ussery, C. (1993) *VHDL Hardware Description and Design*. Menlo Park,California: Kluwer Academic Publishers. 4. Pick, J. (1996) *VHDL: Techniques, Experiments and Caveats*. New Delhi: McGraw Hill Publication. 5. Ott, Douglas E., & Wilderotter, J. *(1994). A Designer's Guide to VHDL Synthesis*. Berlin: Springer. 6. Palnitkar, S. (2003). *Verilog HDL: A Guide to Digital Design and Synthesis*. New Delhi: PHI Publication. 7. Smith, M.J.S. (1997). *Application-*	**~~Deleted~~**

			~~Publishing,(Allentown, PA) 1998.~~ 8. M.J.S .Smith, - "Application - Specific Integrated Circuits" - Addison -Wesley Longman Inc., 1997	*Specific Integrated Circuits.*Boston, New York: Addison Wesley Publication. **Suggested E-resource:** **1. Hardware Modeling using Verilog** by Prof. Indranil Sengupta, Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur https://nptel.ac.in/courses/106105165/1	
4.	**VLSI 512L, HDL Based System Design Lab**	After completion of this laboratory course, students will be able to: • describe the IEEE Standard 1076 Hardware Description Language (VHDL) • Model complex digital systems at several levels of abstractions; behavioral and structural, synthesis and rapid system prototyping. • Develop and simulate register-level models of hierarchical digital systems • Develop a formal test bench from informal system requirements	~~This lab targets to develop an understanding of VLSI design using HDL languages among the students. Different objectives are given to the different group of students to develop a design using Hardware description languages and simulate it using EDA tools.~~	1. Design all gates using VHDL, and verify functionality through simulation outcomes 2. Write VHDL program for Half adder circuit, and verify functionality through simulation outcomes 3. Write VHDL program for Full adder circuit, and verify functionality through simulation outcomes 4. Write VHDL program for Multiplexer circuit, and verify functionality through simulation outcomes 5. Write VHDL program for Demultiplexer circuit, and verify functionality through simulation outcomes 6. Write VHDL program for encoder circuit, and verify functionality through simulation outcomes 7. Write VHDL program for decoder circuit, and verify functionality through simulation outcomes 8. Write VHDL program for D Flip Flop, and verify functionality through simulation outcomes 9. Write VHDL program for T Flip Flop, and verify functionality through simulation outcomes	**Learning Outcomes added** **~~Deleted~~** **Added**

				10. Write VHDL program for SR Flip Flop, and verify functionality through simulation outcomes 11. Write VHDL program for JK Flip Flop, and verify functionality through simulation outcomes 12. Write VHDL program for modulo 8 up Asynchronous counter circuit, and verify functionality through simulation outcomes 13. Write VHDL program for modulo 8 down Asynchronous counter circuit, and verify functionality through simulation outcomes 14. Write VHDL program for modulo 8 up synchronous counter circuit, and verify functionality through simulation outcomes 15. Write VHDL program for modulo 8 down synchronous counter circuit, and verify functionality through simulation outcomes 16. Write VHDL program for shift and add multiplier circuit, and verify functionality through simulation outcomes 17. Write VHDL program for 4 bit ALU, and verify functionality through simulation outcomes 18. Write VHDL program for parallel adder circuit, and verify functionality through simulation outcomes 19. Write VHDL program for sequence detector circuit, and verify functionality through simulation outcomes 20. Write VHDL program for serial adder circuit, and verify functionality through simulation outcomes	
5.	**VLSI 516, IC**	After completion of this course, students will be able	—	—	**No Change in course**

	Fabrication Technology	to: • **U**nderstand thin film deposition and vacuum evaporation process. • Differentiate dry and wet oxidation process and printing methods. • Perform measurement techniques for extracting electrical properties of devices. • Understand diffusion and ion implantation process.	**Text Book:** 1. S. M. Sze, VLSI Technology, McGraw Hill. **Reference Books:** 1. S. K. Gandhi, The Theory and Practice of Microelectronics, John Wiley. 2. D. Nagchoudhuri. Microelectronics technology, Pearson. 3. C. Y. Yang and S. M. Sze, VLSI Technology, Tata McGraw Hill. ~~4. S. M. Sze, Semiconductor Technology.~~	**Recommended Books:** 1. Sze, Simon. (2017). *VLSI Technology*. New Delhi: McGraw Hill Publication 2. Gandhi, S. K. (1994). *The Theory and Practice of Microelectronics.* New Delhi: John Wiley Publication. 3. Nagchoudhuri, D. (2002). *Microelectronics technology*. New Delhi: Pearson Publication. 4. Chang, C. Y.,& Sze, Simon. (1996). *ULSI Technology*. Singapore,Tata McGraw Hill Publication. **Suggested E-resources:** 1. **Introduction to IC fabrication**by Prof. Hardik J Pandya S, Department of Electronic Systems Engineering, IISC, Bangalore. https://nptel.ac.in/courses/108108111/3. **2. MOSFET Fabrication for IC** by Dr. Nandita Dasgupta Department of Electrical Engineering, Indian Institute of Technology, Madras. https://nptel.ac.in/courses/117106093/3.	**contents.** **~~Deleted~~**
6.	**VLSI 516L, IC Fabrication Technology Lab**	After completion of this laboratory course, students will be able to: • Understand fabrication process flow • Understand Silvaco TCAD tool. • understand the procedure to modeling devises and analysing their characteristics	Silvaco 1. Model the fabrication process flow of NMOS with I/V characteristics curve 2. Model the fabrication process flow of PMOS with I/V characteristics curve 3. Model the fabrication process flow of NPN/PNP mos based transistor with input/output characteristics curve. 4. Model the fabrication process flow of pn junction diode.	**All experiments will be performed on Silvaco TCAD Tool.** 1. Model the fabrication process flow of NMOS with I/V characteristics curve 2. Model the fabrication process flow of PMOS with I/V characteristics curve 3. Model the fabrication process flow of NPN/PNP mos based transistor with input/output characteristics curve. 4. Model the fabrication process flow of PN junction diode.	**Added**
7.	**Minor Project (Part-I)**	After completion of this course, students will be able to:	-----	-------	**Learning Outcomes Added and**

		• Formulate the project objectives and deliverables. • Estimate the physical resources required, and make plans to obtain the necessary resources. • Develop plans with relevant people to achieve the project's goals.			**this course has no prescribed syllabus.**
8.	**VLSI 525, Solid State Device Modeling and Simulation**	After completion of this course, students will be able to: • Explain the carrier densities, charge transport, band diagrams and their relations to the device characteristics. • Describe the SPICE device models and apply the basic governing model equations to analyze BJT and MOSFET. • Explain and analyze the operation of optical, microwave and quantum effect devices.	—	—	**No Change in course contents.**
			Text Books: 1. S. M. SZE "Semiconductor Devices Physics and Technology" 2nd Edition WILEY student edition 2. Ben G. Streetman and Sanjay Kumar Banerjee "Solid State Electronics devices" Pearson Education 3. Sung - MO kang, Yusuf Leblebice "CMOS Digital Integrated Circuits Analysis & Design, Tata McGrawhill 4. Sedra/Smith" Microelectronics Circuits" forth edition OXFORD ~~5. PSpice Manuals~~	**Recommended Books:** 1. Sze, S. M. (1985). *Semiconductor Devices Physics and Technology*. New York: Wiley Publication. 2. Streetman, Ben. G.,&Banerjee, Sanjay.Kumar.(2019). *Solid State Electronics Devices*. New Delhi: Pearson Publication. 3. Kang, Sung-Mo., & Leblebici, Yusuf. (2002). *CMOS Digital Integrated Circuits- Analysis and Design*. New Delhi: Tata McGraw-Hill Publication. 4. Smith, Sedra. (2013). *Microelectronics Circuits*. New Delhi: Oxford University Press. **Suggested E-resources:** 1. **Solid State Devices**by Dr. S. Karmalkar, Department of Electronics & Communication Engineering, Indian Institute of Technology, Madras. https://nptel.ac.in/courses/117106091/ **2. Semiconductor Devices**by Prof. Dr. G.S. Visweswaran, Department of	**~~Deleted~~**

				Electronics & Communication Engineering, Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/117102061/	
9.	**VLSI 503, Analog and Mixed Signal IC Design**	After completion of this course, students will be able to: • Design basic cells like current sources, current mirrors and reference circuit. • Explain stability issues and design compensated IC operational amplifiers. • Design and analyze comparators and sample-and-hold circuits. • Illustrate the operation of commonly used data conversion circuits.	—	—	**No Change in course contents.**
			Text Books: 1. Phillip E. Allen and Douglas R. Holberg, CMOS analog circuit design, oxford university press, 2nd edition. 2. D. A. Johns and Martin, Analog Integrated Circuit Design, John Wiley, 1997. 3. R.J.Baker, CMOS Mixed Signal Circuit Design,Wiley/IEEE,2002 **Reference Books:** 1. R Gregorian and G C Temes, Analog MOS Integrated Circuits for Signal Processing, John Wiley, 1986. 2. Paul B Gray and Robert G Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley. 3. R L Geiger, P E Allen and N R Strader, VLSI Design Techniques for Analog & Digital Circuits, MGraw Hill, 1990	**Recommended Books:** 1. Allen, Phillip.E.,& Holberg, Douglas. R. (2002). *CMOS Analog Circuit Design.* New York: Oxford University Press. 2. Johns, D. A., & Martin, Key (1997). *Analog Integrated Circuit Design*. New York: John Wiley and Sons. 3. Baker, R.J. (2008). *CMOS Mixed Signal Circuit Design*. New York: Wiley/IEEE Press 4. Gregorian, R.,& Temes, G. C.(1986). *Analog MOS Integrated Circuits for Signal Processing*. New York: John Wiley Publication. 5. Gray, Paul. B., & Meyer, Robert.G. (2001). *Analysis and Design of Analog Integrated Circuits*. New York: John Wiley Publication. 6. Geiger, R. L.,Allen, P. E.,&Strader, N. R.(1990). *VLSI Design Techniques for Analog & Digital Circuits.* New Delhi: MGraw Hill Publication. **Suggested E-resource:** **1. Analog Integrated Circuit** Design by Prof. Nagendra Krishnapura, Department of Electrical Engineering, Indian Institute of Technology, Madras. https://nptel.ac.in/courses/117106030/	
10.	**VLSI 503L, Analog and**	After completion of this laboratory course, students will be able to:	1. ~~Simulate simple current mirror and determine small signal output resistance.~~ 2. ~~Simulate CASCODE current mirror and~~	1. Design NMOS simple current mirror for channel length of 1 µm and 180 nm and study DC analysis. Compare the results at	

	Mixed Signal IC Design Lab	• Analyse and interpret the waveform, comparison of simulation results with the theoretical analysis. • Ability to use the simulation software for performing the experiments. • Ability to design and test various amplifier circuits, which meets the desired specifications.	~~determine small signal output resistance.~~ ~~3. Design differential amplifier and study its DC and transient response.~~ ~~4. Study of AC response and bandwidth calculation of differential amplifier.~~ ~~5. Study of AC and transient response of differential amplifier.~~ ~~6. Design Common Source (CS) amplifier and study its DC and Transient response.~~ ~~7. Study of frequency response of CS amplifier.~~ ~~8. Design source follower and study its DC and Transient and AC response.~~ ~~9. Design two stage Op-Amp and study of its DC and Transient characteristics and determine Slew rate.~~ ~~10. AC characteristics, UGB and Phase Margin estimation of two stage Op-Amp~~	two different channel lengths. 2. Analyze AC characteristics of the simple current mirror and determine small signal output resistance. Comparison of small signal resistance at different channel lengths. Discuss the results. 3. Draw the schematic of NMOS CASCODE current mirror for channel length of 1 m and analyze DC response. Do the same for 180 nm channel length. Compare and discuss the results. 4. Analyze AC characteristics of the CASCODE current mirror and determine small signal output resistance. Comparison the small signal resistance with simple current mirror. Discuss the results. 5. Design CMOS differential amplifier for a given channel length and draw the schematic cell view of differential amplifier. 6. Create the symbol for the differential amplifier and build the differential amplifier test design. 7. Set up and run simulations (AC, DC and Transient) on the Differential Amplifier Test design. 8. Calculate the gain, bandwidth and CMRR of Differential pair. Discuss the results. 9. Design of current source loaded common source amplifier. create a new cell view and build Common Source Amplifier. Create a symbol for the Common Source Amplifier 10. Build cs_amplifier_test circuit using your cs_amplifier, set up and run simulations(AC, DC and Transient) on the cs_amplifier_test design. 11. Determine the gain, bandwidth and	**Learning Outcomes Added** **Added**

				voltage swing of CS amplifier. Comment on the results. 12. Create a new cell view and build Common Drain (CD) Amplifier. Build CD amplifier test circuit using your CD amplifier. Set up and run simulations(AC, DC and Transient) on the CD amplifier test design. 13. Determine the gain, bandwidth and voltage swing, output resistance of CS amplifier. Comment on the results. 14. Build schematic capture of two stage operational amplifier (OP-AMP) using the previously created symbols of CS amplifier and CD amplifier. Thereafter Create a symbol for the OP-AMP. 15. To build op-amp_test circuit using your op-amp. Set up and run simulations(AC, DC and Transient) of op-amp_test circuit. 16. Determine voltage gain, slew rate, UGB and Phase Margin of two stage Op-Amp and compare with the design specifications. Comments on the results	
11.	**VLSI 504, ASIC Design**	After completion of this course, students will be able to: • Analyze the concept of Full Custom ASIC and Semi-Custom ASIC, Cell Libraries, Data Logic Cells, Low-level Design Entry and Low Level Design Languages • Explain ASIC I/O Cell : DC Output, AC Output, DC Input, AC Input, Clock Input, Power	—	—	**No Change in course contents.**
			Text Books: 1. Mohammed Ismail, Terri Fiez, "Analog VLSI signal and Information processing", McGraw-Hill International Editions, 1994. 2. M.J.S. Smith, - "Application - Specific Integrated Circuits" - Addison -Wesley Long man Inc., 1997 3. Wayne Wolf, FPGA based system design, Pearson education, 2005. **Reference Books:**	**Text Books:** 1. Smith M. J. S. (2006). *Application Specific Integrated Circuits* USA:Pearson Publication 2. Ismail, Mohammed. &Terri, Fiez. (1994). *Analog VLSI signal and Information processing*. New York: McGraw-Hill Publication. 3. Wolf,Wayne. (2005). *FPGA based System Design*. New Delhi: PHI Publication. 4. Brown, Andrew. (1991). *VLSI Circuits*	~~**Deleted**~~

		Input and PLA Tools. • Describe Programmable ASIC Logic Cell, FPGA Logic Cells, and Programmable Interconnects to Solve the RC delay of routing resources for each ASIC.	1. Malcom R.Haskard, Lan C.May, "Analog VLSI Design - NMOS and CMOS" Prentice Hall, 1998. 2. Randall L Geiger, Phillip E. Allen, "Noel K.Strader, VLSI Design Techniques for Analog and Digital Circuits", Mc Graw Hill International Company, 1990. 3. Jose E.France, Yannis Tsividis, "Design of Analog-Digital VLSI Circuits for Telecommunication and signal processing", Prentice Hall, 1994. 4. Andrew Brown, - "VLSI Circuits and Systems in Silicon", McGraw Hill, 1991. 5. S.D. Brown, R.J. Francis, J. Rox, Z.G. Uranesic, "Field Programmable Gate Arrays"- Kluwer Academic Publishers, 1992. ~~6. Mohammed Ismail and Terri Fiez, "Analog VLSI Signal and Information Processing ", Mc Graw Hill, 1994.~~ ~~7. S. Y. Kung, H. J. Whilo House, T. Kailath, "VLSI and Modern Signal Processing", Prentice Hall, 1985.~~	*and Systems in Silicon*. New York: McGraw-Hill Publication. 5. Haskard, Malcom. R., & May, Lan C. (1998). *Analog VLSI Design - NMOS and CMOS*. New Delhi: PHI Publication. 6. Geiger, Randall. L., Allen, Phillip E., & Strader, Noel.K. (1990). *VLSI Design Techniques for Analog and Digital Circuits*. New Delhi: PHI Publication. 7. France, Jose.E.,& Tsividis,Yannis. (1994). *Design of Analog-Digital VLSI Circuits for Telecommunication and Signal Processing*. New Delhi: PHI Publication. 8. Brown, S.D.,Francis, R.J., Rox, J., &Uranesic, Z.G. (1992). *Field Programmable Gate Arrays*. Menlo Park,California: Kluwer Academic Publishers. **Suggested E-resource:** **1. Digital VLSI Systems Design**by Prof. S. Srinivasan, Department of Electrical Engineering, Indian Institute of Technology, Madras. https://nptel.ac.in/courses/117106092/	
12.	**VLSI 505, CAD for IC Design**	After completion of this course, students will be able to: • Student will understand Basic concept of describing VLSI design problems • Student will understand graph	—	—	**No Change in course contents.**
			Text Books: 1. S.H. Gerez, "Algorithms for VLSI Design Automation", John Wiley & Sons, 2002. 2. N.A. Sherwani, "Algorithms for VLSI Physical Design Automation", Kluwar	**Recommended Books:** 1. Gerez, S.H. (2002). *Algorithms for VLSI Design Automation.* New York: John Wiley Publication. 2. Sherwani, N.A. (2002). *Algorithms for VLSI Physical Design Automation*. Boston, New York: Kluwar Academic	**~~Deleted~~**

		theory and its utilization in finding solution for VLSI design problems. • To understand algorithms to solve various VLSI design problem like floorplaning, scheduling, placement, routing etc.	Academic Publishers, 2002. 3. Drechsler, R., "Evolutionary Algorithms for VLSI CAD, Kluwer Academic Publishers, Boston, 1998. 4. Hill, D., D. Shugard, J. Fishburn and K. Keutzer, Algorithms and Techniques for VLSI Layout Synthesis, Kluwer Academic Publishers, Boston, 1989. 5. Giovanni De Micheli, "Synthesis and Optimization of Digital Circuits" TMH. ~~6. Sadiq M. Sait and Habib Youssef, "VLSI PHYSICAL DESIGN AUTOMATION Theory and Practice" IEEE PRESS.~~	Publishers. 3. Drechsler, R. (1998). *Evolutionary Algorithms for VLSI CAD*. Boston, New York: Kluwer Academic Publishers. 4. Hill, D., Shugard, D., Fishburn, J.,& Keutzer, K. (1989). *Algorithms and Techniques for VLSI Layout Synthesis*. Boston, New York: Kluwer Academic Publishers. 5. Micheli, Giovanni.De.(2003). *Synthesis and Optimization of Digital Circuits*. New Delhi: TMH Publication. **Suggested E-resource:** 1. **CAD for VLSI Design I** by Prof. Prof. V. Kamakoti and Prof Shankar Balachandran, Department of Computer Science and Engineering, Indian Institute of Technology, Madras https://nptel.ac.in/courses/106106088/	
13.	**VLSI 505L, CAD for IC Design Lab**	After completion of this laboratory course, students will be able to: • Understand the VLSI design automation. • Understand the process to develop and analyse synthesis outcomes. • Demonstrate knowledge of computational and optimization algorithms and tools, applicable to solving CAD related problems.	~~This lab targets to develop an understanding of design automation among the students. Different objectives are given to the different group of students to develop a design, simulate and synthesize it using EDA tools~~.	1. NETLIST generation and analysis of Half Adder 2. NETLIST generation and analysis of Full Adder 3. NETLIST generation and analysis of Half Subtractor 4. NETLIST generation and analysis of Full Subtractor 5. NETLIST generation and analysis of Multiplexer 6. NETLIST generation and analysis of Demultiplexer 7. NETLIST generation and analysis of D Flip Flop 8. NETLIST generation and analysis of T Flip Flop 9. NETLIST generation and analysis of JK Flip Flop 10. NETLIST generation and analysis of SR	**Learning Outcomes Added** **Added**

				Flip Flop 11. NETLIST generation and analysis of Four bit Binary Counter 12. NETLIST generation and analysis of Serial in Serial Out Shift Register 13. NETLIST generation and analysis of Parallel in Serial Out Shift Register 14. NETLIST generation and analysis of Serial in Parallel Out Shift Register **15.** NETLIST generation and analysis of Ripple Carry Adder	
14.	**Minor Project (Part-II)**	After completion of this course, students will be able to: • Identify, formulate, and solve VLSI design problems using advanced level manufacturing and design techniques • Apply advanced level knowledge, techniques, skills and modern tools of VLSI Design. • Understand the complexities and design methodologies of current and advanced VLSI design technologies.	-----	------	**Learning Outcomes Added and this course has no prescribed syllabus.**
15.	**VLSI 524, RF IC Design**	After completion of this course, students will be able to: • Understand basics concepts of radio frequency integrated systems and their performance parameters. • Identify design trade-off	—	—	**No Change in course contents.**
			Texts/Reference Books: 1. B.Razavi, RF Microelectronics, Prentice-Hall PTR,1998 2. T.H.Lee, The Design of CMOS Radio-Frequency Integrated Circuits", Cambridge University Press, 1998.	**Recommended Books:** 1. Razavi, B. (2011). *RF Microelectronics*. New Delhi: PHI Publication. 2. Lee,T.H. (1998). *The Design of CMOS Radio-Frequency Integrated Circuits*. New York: Cambridge University Press. 3. Baker, R.Jacob., Li, H.W., & Boyce, D.E.	

		used in various transmitters and receivers architecture with wireless standards. • Perform VLSI implementation of oscillators, Mixers and Power amplifiers.	3. R.Jacob Baker,H.W.Li, and D.E. Boyce, CMOS Circuit Design ,Layout and Simulation, Prentice-Hall of India,1998. 4. Y.P. Tsividis Mixed Analog and Digital VLSI Devices and Technology, McGraw Hill, 1996.	(1998). *CMOS Circuit Design, Layout and Simulation*. New Delhi: PHI Publication. 4. Tsividis, Y.P. (1996). *Mixed Analog and Digital VLSI Devices and Technology*. New York: McGraw Hill Publication. **Suggested E-resources:** 1. **RF System - Basic Architectures** by Prof. Dr. S. Chatterjee, Department of Electrical Engineering Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/117102012/. 2. **RF integrated Circuits** by S. Aniruddhan, Department of Electrical Engineering, IIT Madras.http://www.ee.iitm.ac.in/~ani/2011/ee6240/pdf/ee6240_lec32.pdf.	
16.	**Project (Part-I)**	After completion of this course, students will be able to: • Recognize the need to engage in lifelong learning through continuing education and research. • Formulate the project objectives and deliverables. • Estimate the physical resources required, and make plans to obtain the necessary resources. • Develop plans with relevant people to achieve the project's goals.	-----	-------	**Learning Outcomes Added and this course has no prescribed syllabus.**
17.	**Project**	After completion of this	----	----	**Learning**

	(Part-II)	course, students will be able to: • Demonstrate knowledge of contemporary issues in the area of VLSI design. • Manage projects related to VLSI design in multidisciplinary environments. • Understanding the Functioning with multidisciplinary teams, working cooperatively, respectfully, creatively and responsibly as a member of a team.			**Outcomes Added and this course has no prescribed syllabus.**
18.	**CS 429, Pattern Recognition and Image Processing**	After completion of this course, students will be able to: • Explain the concept of Image Processing, Mathematical preliminary of Image Processing and various Image Representations. • Analyze the methods of Image Enhancement and Image Filtering, • Identify different image analysis and pattern recognition methods and apply them in problem areas also develop an abundance of Image Processing applications that can serve mankind with the available and	—	—	**No Change in course contents.**
			Text Books: 1. Jain A. K., Fundamentals of digital image Processing, PHI Publications. 2. Gozalez Rafel, Woods Richard, Digital Image Processing, Pearson Education. **Reference Books:** 1. Rosenfield, A and Kak A. C, Picture Processing, Academic Press N.Y. 1982 2. Pratt, W. K., Digital Image Processing, John Willey and sons, New York. 3. Duda R., Hart Peter, Stork D., Pattern Classification, Willey Interscience Publication. 4. Manahem Friedman, Abraham Kandel, Introduction to Pattern Recognition, World Scientific.	**Recommended Books:** 1. Jain A. K. (2015). *Fundamentals of Digital Iimage Processing*. New Delhi: PHI Publication. 2. Rafel, Gozalez.,& Richard, Woods. (2016). *Digital Image Processing*. New Delhi: Pearson Publication. 3. Rosenfield, A., & Kak, A. C.(1982). *Picture Processing*. Orlando, Florida: Academic Press. 4. Pratt, W. K. (2007). *Digital Image Processing.*Hoboken, New Jersey: John Willey and sons, Publication. 5. Friedman, Manahem.,& Kandel, Abraham.(1999). *Introduction to Pattern Recognition*. Singapore: World Scientific. 6. Charniak, E.,& Mcdermott, D. (1985). Introduction to Artificial Intelligence.	

		anticipated technology in the near future.	5. E. Charniak, D. Mcdermott, Introduction to Artificial Intelligence, Addison Wesley.	Boston, New York: Addison Wesley. **Suggested E-resources:** **1. Pattern Recognition and Application** by Prof. P. K. Biswas, Department of Electronics and Electrical Communication Engineering, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105101/	
19	**CS 431, Real Time Systems**	After completion of this course, students will be able to: • To present the mathematical model of the system • Analyse multi task scheduling algorithms • To explain Reliability Evaluation techniques and Real time communication algorithms	—	—	**No Change in course contents.**
			Text Book: 1. Krishna C.M, Shen K.G, Real Time Systems, Mc. Graw Hill, **References Books:** 1. Lawrence P.D, Mauch, K, Real Time Microcomputer Design: An Introduction , Mc. Graw Hill, 2. Joseph Mathai, Real Time systems : Specification, verification & analysis ,Prentice Hall Inc. 3 Bennet Stuart , Real Time computer control ,Prentice Hall Inc., ~~4. Young S. J., Real time languages, John willey & sons.~~	**Recommended Books:** **1.** Krishna, C.M., & Shen, K.G. (2008). *Real Time Systems*. New Delhi: McGraw Hill Publication. 2. Lawrence, P.D., & Mauch, K.(1998). *Real Time Microcomputer Design: An Introduction*. New York: McGraw Hill Publication. 3. Mathai, Joseph.(1996). *Real Time systems: Specification, Verification & Analysis*. London, PHI Publication. **4.** Stuart, Bennet.(1994). *Real Time Computer Control*. ,New Jersey: PHI Publication.	~~**Deleted**~~
20	**ELE 502, Discrete Time Signal Processing**	After completion of this course, students will be able to: • Apply discrete-time signal processing techniques analysis to perform various signal operations. • Apply the principles of Fourier transform	—	—	**No Change in course contents.**
			Text Books: 1. J.G.Proakis and D.G.Manolakis, Digital Signal Processing : Principles, Algorithms and Applications, Third Edition, PH, 1996. 2. I.J.Nagarath, S.N.Sharan, R.Ranjan	**Recommended Books:** 1. Proakis, J.G.& Manolakis, D.G. (2014). *Digital Signal Processing: Principles, Algorithms and Applications*.New Jersey: Pearson Publication. 2. Nagarath, I.J.,Sharan, S.N.,Ranjan, R.,& Kumar, S. (2009). *Signals and Systems,*	~~**Deleted**~~

		analysis to describe the frequency, and characteristics of discrete-time signals and systems. • Understand the design techniques of various digital and analog filters.	and S.Kumar, Signals and Systems, TMH, 2001. 3. A.V.Oppenheim, R.W.Schafer and J.R.Buck, Discrete-Time Signal Processing, Second Edition, PH, 1998. 4. ~~S.K.Mitra, Digital signal processing : A computer Based Approach, Second Edition,MH,2000.~~	New Delhi: TMH Publication. 3. Oppenheim, A.V., Schafer, R.W., & Buck, J.R. (1998). *Discrete-Time Signal Processing*. New Jersey: PHI Publication. **Suggested E-resources:** 1. **Discrete Time Signal Processing** by Prof. Mrityunjoy Chakraborty, Department of Electronics and Electrical Communication Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105134/. 2. **Digital Signal Processing** by Prof: S. C. Dutta Roy, Department of Electrical Engineering Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/117102060/.	
21	**VLSI 501, Advanced Digital Signals Processing**	After completion of this course, students will be able to: • Modelling of random filter and identification of different parameters. • Realization of Kalman filters and concept of spatial smoothing. • Adaptive implementation of wiener filter and Adaptive noise cancelling.	—	—	**No Change in course contents.**
			Text Books: 1. S.J.Orfanids, Optimum Signal Processing: An Introduction, Second edition, MacMillian/MH, 1988. (Out of Print) 2. ~~J.G.Proakis, C.M.Rader,F.Ling and C.l.Nikias, Advanced Digital Signal Processing,MacMillian,1992.(Out of Print)~~ **References Books:** ~~1. D.G.Manolakis, V.Ingle and S.Kogon, Statically and Adaptive Signal Processing, MH, 2000.~~ ~~2. J.G.Proakis, C.M.Rader, F.Ling, M.Moonen, I.K.Proudler and C.l.Nikias, Algorithms for Statistical~~	**Recommended Books:** 1. Orfanids, S.J. (1988). *Optimum Signal Processing: An Introduction*. New York: Collier Macmillan Publication. **Suggested E-resource:** 1. **State space Models** by Professor Anna Mikusheva Paul Schrimpf. https://ocw.mit.edu/courses/.../14.../MIT14_384F13_lec21.pdf 2. **Adaptive signal Processing** by Prof. Mrityunjoy Chakraborty, Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105075/5	**~~Deleted~~**

			~~Signal Processing, PH/Pearson, 2002.~~ ~~3. J.V.Candy, Signal Processing, MH,1986.(Out of Print)~~ ~~4. B.Mulgrew and C.F.Cowan,Adaptive Filters and Equalizers, Kulwer,1998.(Out of print)~~		
22	**VLSI 502, Advanced Digital System Design**	After completion of this course, students will be able to: • Formulate and solve problems in Digital Systems design. • Knowledge about the properties of symmetric networks and apply threshold logic on digital circuits. • Analyze digital system design using PLD.	—	—	**No Change in course contents.**
			Text Books: 1. ~~Brian Holdworth & Clive Wood, "Digital logic Design" - Elsevier-2005.~~ 2. Nripendra N. Biswas, "Logic Design theory, "PHI, 2005. 3. ZVI Kohavi, "Switching and Finite Automata theory", second edition, Tata Mcgraw Hill, 2001. 4. William I. Fletcher, "An Engineering Approach to Digital Design, PHI, 2003. 5. Randall L. Geiger, Phillip E. Allen, Noel k strader, "VLSI Design Techniques for Analog Digital circuits, "McGraw hill, 1990. 6. ~~John F. Warkerly, "Digital Design Principles & practices, III editions, Pearson, education, 2005.~~	**Recommended Books:** 1. Biswas, Nripendra.N. (2001) *Logic Design theory*. New Delhi: PHI Publication. 2. Kohavi, ZVI. (2010) *Switching and Finite Automata theory*. New York: Cambridge University Press. 3. Fletcher, William. I. (1997) An *Engineering Approach to Digital Design*. New Delhi: PHI Publication. 4. Geiger, Randall. L., Phillip E. Allen., & Strader, Noel. R. (1989) *VLSI Design Techniques for Analog and Digital Circuits*. Boston, Massachusetts: McGraw Hill Publication. **Suggested E-resources:** 1. **Programmable logic devices** Prof. D. Roychoudhury Department of Computer Science and Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105080/26. 2. **Digital Systems Design** with PLDs and FPGAs Kuruvilla Varghese Department of Electronic Systems Engineering Indian Institute of Science, Bangalore. https://nptel.ac.in/courses/117108040/.	**~~Deleted~~**
23	**VLSI 506, Design of Semiconduc**	After completion of this course, students will be able to:	—	—	**No Change in course contents.**

	tor Memory	• Know about architecture of semiconductor memories and methodologies adopted in data storage. • Analyze the difference in volatile and non-volatile memory, and their building blocks. • Know memory fault tolerance and testing methodology.	—	**Recommended Books:** 1. Betty, Prince. (1996). *Semiconductor Memories: A Handbook of Design, Manufacture and Application*. New York: Willey Publication. **Suggested E-resources:** 1. **Design of memory circuits** by Prof. D Roychoudhry Department of Computer Science and Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105080/31.	**Added**
24	**VLSI 510, Embedded System Design**	After completion of this course, students will be able to: • Explain the challenges in the design of embedded system • Describe the Hardware and Software Tools for Embedded System • Describe the Features of OS and language for Embedded System	—	—	**No Change in course contents.**
			Text Books: 1. W. Wolf, Computers as Components: Principles of Embedded Computer System Design, Morgan Kaufmann, 2000. 2 F.Vahid and T.D Givargis , Embedded System Design : A unified Hardware/ software Introduction ,Wiley.2002. **Reference Books:** 1. ~~S.Health, Embedded System Design, Second Edition Butterworth-Heinemann, 2002~~ 2. ~~D. Patterson and J Hennessy .Computer Organization and Design: The Hardware/software Interface, Second Edition ,Morgan Kauffman ,1997~~ 3. ~~A .S.Berger, Embedded System Design : An Introduction to Processes ,Tools~~	**Recommended Books:** 1. Wolf, M. (2012). *Computers as components: principles of embedded computing system design*. Elsevier. 2. Vahid, F., & Givargis, T.D.(2002) *Embedded System Design:A unified Hardware/ software Introduction.* New Jersey: Wiley Publication. 3. Gannsle, J. (2008) *The Art of Designing Embedded System*. New Delhi: Newnes Publication. 4. Staunstrup, J.,& Wolf,W. (1997) *Hardware /software Codesign: Principles and Practice.* Boston, Massachusetts: Springer Publications. 5. Gajski, D.D., Vahid, F., Narayan, S., & Gong, j. (2007). *Specification design of Embedded System.* New Delhi: Pearson Education India. **Suggested E-resources:** 1. **Embedded Systems - Shape The World: Microcontroller Input/Output** by The University of Texas at Austin	**~~Deleted~~**

			~~and technique. CMP Books, 2001.~~ 4. J. Gannsle,The art of Designing Embedded System ,Newnes. 1999. 5. ~~L. Edwards, Embedded System Design on a Shestring ,Newnes .2003~~ 6. ~~J. Catsoulis. Designing embedded Hardware, ORA,2002~~ 7. ~~J. J. Labrosse, Embedded System Building Blocks .CMP Books ,1999.~~ 8. J. Staunstrup and W.Wolf, Hardware /software Codesign: Peinciples and Practice, Kluwer 1997. 9. D.D.Gajski.F.Vahid ,S.Narayan and j.gong ,specification and Design of Embedded System ,PH/Pearson, 1994. 10. ~~G.de Micheli, R.Ernst and W.Wolf ,Reading in Hareware/software Codesign ,Morgan Kaufmann ,2001~~	(UTAustinX), https://www.edx.org/course/embedded-systems-shape-the-world-microcontroller-inputoutput 2. **Embedded Systems** by Georgia Tech as CS, 8803 https://in.udacity.com/course/embedded-systems--ud169 3. **Embedded System Design** with ARM by Dr. Kamalika Datta Indian Institute of Technology, Kharagpur, https://onlinecourses.nptel.ac.in/noc19_cs22/preview	
25	**VLSI 511, Fault Tolerance in VLSI**	After completion of this course, students will be able to: • Diagnose and measure different type of Faults. • Explain the detection, correction techniques and fault-tolerant networks • Analyze fault tolerance strategies and enhance capabilities about applications of fault tolerant designs in arithmetic units and systems.	—	—	**No Change in course contents.**
			Reference Books: 1. Victor P. Nelson and Bill D. Carroll, Tutorial: Fault-Tolerant Computing, IEEE Computer Society Press, 1987, ISBN: 0-8186-06770 2. D.K. Pradhan (ed.), Fault Tolerant Computer System Design, Prentice-Hall, 1996. 3. ~~D.P. Siewiorek and R.S. Swarz, A.K. Peters, Reliable Computer Systems: Design and Evaluation, 1998.~~	**Recommended Books:** 1. Nelson, Victor. P.,&Carroll, Bill. D. (1987). *Tutorial: Fault-Tolerant Computing*, Maryland: IEEE Computer Society Press. 2. Pradhan, D.K. (1996). *Fault Tolerant Computer System Design*. New Jersey: PHI Publication. 3. Johnson, B.W. (1989) *Design and Analysis of Fault-Tolerant Digital Systems*. Boston, Massachusetts: Addison-Wesley.	**~~Deleted~~**

		• Explain the basic mechanisms of fault-tolerance methods and fault tolerant computer systems.	4. B.W. Johnson, Design and Analysis of Fault-Tolerant Digital Systems, Addison-Wesley, 1989	**Suggested E-resources:** **1. VLSI Design Verification and Test** by Prof. Jatindra Kumar Deka and Dr. Santosh Biswas, Department of CSE, IIT Guwahati.https://nptel.ac.in/courses/106103016/	
26	**VLSI 513, High Level System Design and Modeling**	After completion of this course, students will be able to: • Understand describing a system • Understand about information system and models • Understand system analysis and system design	—	—	**No Change in course contents.**
			Books:- 1. Embedded System Design- Modeling, Synthesis, Verification by Dainel D.Gajaski, Samer Abdi Springer. 2. Specification and Design of Embedded Systems by Daniel D. Gajski, PTR Prentice Hall Englewood New Jersey	**Recommended Books:** 1. Dainel D.Gajaski., & Abdi, Samer. (2009). *Embedded System Design-Modeling, Synthesis.* New York: Springer Publication. **2.** Daniel D. Gajski. (1994). *Specification and Design of Embedded Systems*. New Jersey: PHI Publication.	
27	**VLSI 514, High Power Semiconductor Devices**	After completion of this course, students will be able to: • Get knowledge of power semiconductor devices under extreme operation conditions like high voltage, high current and high temperature which are encountered under typical power electronic environment. • Understand knowledge developed from this, will help in designing power devices with desired specifications. • Get knowledge of VMOS, CMOS, DMOS Devices.	—	—	**No Change in course contents.**
			Texts/References Book: • S.M. Sze, Physics of Semiconductor Devices, 2nd ed., Wiley, 1981	**Recommended Books:** 1. Sze, S.M. (1981). *Physics of Semiconductor Devices*. New York: Wiley Publication. **Suggested E-resources:** 1. **Basic Device models** by Prof. Roshan Bhosh Department of Electronics and Electrical Communication Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105084/. 2. **Semiconductor Device Modeling** by Prof. Shreepad Karmalkar Department of Electrical Engineering Indian Institute of Technology- Madras, https://nptel.ac.in/courses/117106033/.	

28	**VLSI 515, High Speed VLSI Design**	After completion of this course, students will be able to: • Design Clocked logic styles non clocked logic styles. • Understand knowledge of circuit designing margining. • Get knowledge of Clock generation and distribution.	—	—	**No Change in course contents.**
			Reference Books: 1. Kerry Bernstein & et. al., High Speed CMOS Design Styles, Kluwer, 1999. 2. Evan Sutherland, Bob stroll, David Harris, Logical Efforts, Designing Fast CMOS Circuits, Kluwer, 1999. 3. David Harris, Skew Tolerant Domino Design.	**Recommended Books:** 1. Bernstein, Kerry. (1999). *High Speed CMOS Design Styles*. New Jersey: Kluwer Academic Publishers. 2. Sutherland, Evan., Stroll,Bob.,& Harris, David.(1999) *Logical Efforts, Designing Fast CMOS Circuits*. Boston, Massachusetts: Kluwer Academic Publishers. 3. Harris, David.(2000*). Skew Tolerant Domino Design*. New Delhi: Elsevier. **Suggested E-resources:** 1. **High Speed Devices and Circuits** by Prof. K. N. Bhat Department of Electrical Engineering Indian Institute of Technology, Madras. https://nptel.ac.in/courses/117106089/ 2. **CMOS VLSI Circuit** by Prof. A. N. Chandorkar Department of Electrical Engineering Indian Institute of Technology, Bombay. https://nptel.ac.in/courses/117101004/	
29	**VLSI 517, Integrated Electronic System Design**	After completion of this course, students will be able to: • Understanding, gathering and processing of electronics system through basic Motherboard, PCB and IC technologies. • Design their own circuits based on the knowledge learnt from class. • Get the opportunity to become proficient in using	—	—	**No Change in course contents.**
			Text Books: 1. ~~W.J.Dally and J.W.Poulton, Digital System Engineering, CUP, 1998.~~ 2. ~~N.Storey, Electronics: A System Approach, AW/Pearson, 1998/2000.~~ 3. S.D.Burd, System Architectures, Thomson, 2001. **Reference Books:**	**Text Books:** 1. Burd, S.D. (2001). *System Architectures*. New Delhi: Thomson learning Publication. 2. Cady, F.M. (2009) *Microcontrollers and Microcomputers: Principles of Software and Hardware Engineering*. New York: Oxford University Press. 3. Predko, M. (1998) *Handbook of Microcontrollers*. New York: McGraw-	**~~Deleted~~**

		the 8051 microcontroller for circuit modeling and analysis.	~~1. G.Lipovski, Introduction to Micro-Controllers (MC 68HC12), AP, 1999.~~ ~~2. G.Lipovski, Single and Multi-Chip Micro-Controller Interfacing (MC 68HC12), AP, 1999.~~ 3. F.M.Cady, Microcontrollers and Microcomputers: Principles of Software and Hardware Engineering, OUP, 1997. 4. M.Predko, Handbook of Microcontrollers, MH, 1998.	Hill. **Suggested E-resources:** 1. **Microprocessors and Microcontrollers** by Prof. Santanu Chattopadhyay Department of E & EC Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/108105102/23 2. **Principles of Communication Systems - Part II** by Prof. Aditya K. Jagannatham Department of Electrical Engineering Indian Institute of Technology, Kanpur. https://nptel.ac.in/courses/108104098/7	
30	**VLSI 518, Introduction to MEMS**	After completion of this course, students will be able to: • Be familiar with the important concepts applicable to MEMS, their fabrication. • Be fluent with the design, analysis and testing of MEMS. • Get knowledge of micro fabrication, micro actuators and surface micromachining and applications.	—	—	**No Change in course contents.**
			Text & References Books: 1. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001. 2. Marc Madou, "Fundamentals of Microfabrication" by, CRC Press, 1997. 3. Gregory Kovacs, "Micromachined Transducers Sourcebook" WCB McGraw-Hill, Boston, 1998. 4. M.-H. Bao, "Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes" by Elsevier, New York, 2000.	**Recommended Books:** 1. Senturia, Stephen. D. (2001) *Microsystem Design*. Norwell, Massachusetts:Kluwer Academic Publishers. 2. Madou, Marc.(1997). *Fundamentals of Microfabrication*. California: CRC Press. 3. Kovacs, Gregory. (1998) *Micromachined Transducers Sourcebook.* Boston, Massachusetts: WCB McGraw-Hill Publication. 4. Bao, M.-H. (2000). *Micromechanical Transducers: Pressure Sensors, Accelerometers, and Gyroscopes*. New York: Elsevier Publication **Suggested E-resources:** 1. **MEMS and Microsystems** Prof. Santiram Kal Department of Electronics and Electrical Communication Engineering Indian Institute of Technology, Kharagpur. https://nptel.ac.in/courses/117105082/4	

				2. **Microsensors** by Prof. G.K. Ananthasuresh, Department of Mechanical Engineering Indian Institute of Science Bangalore. https://nptel.ac.in/courses/112108092/module1/lec03.pdf	
31	**VLSI 519, Low Power VLSI Design**	After completion of this course, students will be able to: • Learn the design techniques low voltage and low power CMOS circuits for various applications. • Design and implementation of various design structures of flip flop for low power applications. • Design the different types of memory circuits and various CMOS static and dynamic logic circuits • Understand the mechanisms of power estimation and datapath width adjustment	—	—	**No Change in course contents.**
			Text and Reference Books: 1. M. Pedramand J. Rabaey (Editors), Power Aware Design Methodologies, Kluwer Academic Publishers, Boston, 2002 2. Sung - Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated circuits-Analysis and Design", TMH, 3rd Edition.	**Recommended Books:** 1. Roy, Kaushik. & Prasad, Sharat. C. (2009). *Low Power CMOS VLSI Circuit Design*. Dublin: Willey Publications. 2. Pal, Ajit. (2015). *Low Power VLSI Circuits and Systems*. New Delhi: Springer Publications. 3. Pedramand, M.,& Rabaey, J.M.(2002) *Power Aware Design Methodologies*. Boston, Massachusetts: Kluwer Academic Publishers. 4. Kang, Sung – Mo., & Leblebici, Yusuf. (2002). *CMOS Digital Integrated circuits- Analysis and Design*. New Delhi: TMH Publications. **Suggested E-Resources:** **1. Low Power VLSI Circuits and Systems** by Prof. Ajit Pal, Department of Computer Science and Engineering, IIT Kharagpur. https://nptel.ac.in/syllabus/106105034/	**Added**
32	**VLSI 520, Nanoelectronics**	After completion of this course, students will be able to: • Get knowledge in electronics has been driven by miniaturization. • Understand CMOS and MOSFET scaling,	—	—	**No Change in course contents.**
			Reference Books: 1. Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens,Wiley (2003). 2. Nanoelectronics and Information Technology (Advanced Electronic	**Recommended Books:** 1. Poole , C.P., & Owens, F.J. (2003). *Introduction to Nanotechnology*. New York: Wiley Publications. 2. Waser, R. (Ed.). (2012). *Nanoelectronics*	~~**Deleted**~~

		• Understand the electronic properties of molecules, carbon nanotubes and crystals.	Materials and Novel Devices), Waser Ranier, Wiley-VCH (2003) 3. Nanosystems, K.E. Drexler, Wiley (1992) 4. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998 5. ~~Research Papers~~	*and information technology*. John Wiley & Sons. 3. Drexler, K.E. (1992). *Nanosystems*. New York: Wiley Publications. 4. Davies, John. H. (1998). *The Physics of Low-Dimensional Semiconductors*. New York: Cambridge University Press. **Suggested E-resources:** 1. **Nanostructures and Nanomaterials: Characterization and Properties** by Prof. Anandh Subramaniam and Prof. Kantesh Balani Department of Materials Science & Engineering Indian Institute of Technology, Kanpur. https://nptel.ac.in/courses/118104008/ **2. Nanoelectronics: Devices and Materials** by Prof. Navakanta Bhat Centre for Nano Science and Engineering Indian Institute of Science, Bangalore. http://textofvideo.nptel.ac.in/117108047/lec1.pdf	
33	**VLSI 523, Representation and Analysis of Random Signals**	After completion of this course, students will be able to: • understand the theory and application of probability, random variables and random processes • understand to study and analyze analytical expression	—	—	**No Change in course contents.**
			Text Book: • Michel .K Ochi, Applied Probability and Stochastic Processes in Engineering and Physical Sciences, Wiley, 1992. **Reference Books:** 1. A. Papoulis, Probability, Random Variables and Stochastic Processes, MH, 1985. 2. K.S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Application, PH, 1982.	**Recommended Books:** 1. Ochi, Michel .K. (1990) *Applied Probability and Stochastic Processes in Engineering and Physical Sciences*. New York: Wiley Publications. 2. Papoulis, A. (2002). Probability, Random Variables and Stochastic Processes. New York: TMH Publications. **3.** 2. Trivedi ,K.S. (2001). *Probability and Statistics with Reliability, Queuing and Computer Science Application*. New York: Wiley Publications.	

34	**VLSI 526, Speech Signal Processing**	After completion of this course, students will be able to: • Describe the fundamentals of digital speech processing and digital model for speech signal process. • Illustrate and analyze the time domain model and Fourier representation for speech processing. • Explain basic principles of LPC equations and solutions.	—	—	**No Change in course contents.**
			Text Books: 1. L.R.Rabiner and R.W.Schafer, Digital Processing of Speech Signals, PH, 1978. 2. C.Plett, J.W.M.Rogers and M.A.Copeland, Radio Frequency Integrated Circuit Design,Artech,2003 3. R.E.Best, Phase-Locked Loops: Design, Simulation and Application , Fifth Edition,MH,2003 4. ~~D.H.Wolaver, Phase-locked Loop Circuit Design, PH, 1991.~~ **Reference Books:** 1. J.R. Deller ,J.H.L .Hansen and J.G. Proakis, Discrete-time Processing of Speech signals,Wiley/IEEE,2000. 2. T.F. Quatieri, Discrete-Time Speech Processing: Principles and Practices, PH, 2001.	**Recommended Books:** 1. Rabiner, L.R., & Schafer, R.W. (1978). *Digital Processing of Speech Signals*. New Delhi: PHI Publications. 2. Plett, C.,Rogers, J.W.M., &Copeland, M.A. (2003). *Radio Frequency Integrated Circuit.* New Jersey: Design Artech House Publishers. 3. Best, R.E. (2003). *Phase-Locked Loops: Design, Simulation and Application*. New York: TMH Publication. 4. Deller, J.R., HansenJ.H.L ., & Proakis, J.G. (1999). *Discrete-time processing of Speech Signals*. New York: Wiley-IEEE Press. 5. Quatieri, T.F. (2001). *Discrete-Time Speech Processing: Principles and Practices*. Massachusetts: PHI Publications. **Suggested E-resource:** 1. **Digital Speech Processing** by Prof. S. K. Das Mandal Centre for Educational Technology Indian Institute of Technology, Kharagpur .https://nptel.ac.in/courses/117105145/19	**~~Deleted~~**
35	**Photonics Integrated Circuits**	After completion of this course, students will be able to: • Describe the optical waveguides and optical couplers with the help of coupled mode theory		**Section A** Optical Waveguide Modes, Planar Waveguides, Symmetric and Asymmetric, Slab and channel waveguides, Optical Couplers: Prism Couplers, Gräting Couplers, Tapered Couplers, Fiber to Waveguide Couplers, Multilayer Planar Waveguide Couplers, Dual-Channel Directional	**New Course Added as elective.**

		• Explain the basic operating mechanisms of optical switches and modulators • Identify the performance limiting factors and applications of integrated optics		Couplers, Coupled-Mode Theory.	
				Section B Electro-Optic Modulators: Basic Operating Characteristics of Switches and Modulators, The Electro-Optic Effect, Single-Waveguide Electro-Optic Modulators, Dual-Channel Waveguide Electro-Optic Modulators. Acousto-Optic Modulators: Acousto-Optic Effect, Raman-Nath-and Bragg Type Modulators, Acousto-Optic Frequency Shifters.	
				Section C Distributed-Feedback Lasers: Theoretical Considerations and performance characteristics, Integrated Optical Detectors: Depletion Layer Photodiodes, Specialized Photodiode Structures, Techniques for Modifying Spectral Response, performance limiting factors. Applications of Integrated Optics and Current Trends: Opto-Electronic Integrated Circuits and future projections.	
				Recommended Books: 1. Hunsperger, Robert. G. (1995). *Integrated Optics Theory and Technology*. Berlin, New York: Springer. 2. Nishihara, Hiroshi. Haruna, Masamitsu.,& Suhara, Toshiaki. (1989). *Optical integrated circuits.* New York: McGraw-Hill Publication. 3. Reed, Graham. T., & Knights, Andrew. P. (2004). *Silicon photonics: An Introduction.* New York: John Wiley & Sons. 4. Tamir,T.(1990). *Guided wave Opto-electronics*. Berlin, Heidelberg: Springer. **Suggested E- resource:**	

				1. **Photonic Integrated Circuits** by Dr. Srinivas Talabatulla, Department of Electronics & Communication Engineering, IISc, Bangalore. https://nptel.ac.in/courses/117108142/	
36	**VLSI 601R, High Level Synthesis**		**Section A** Introduction: Level of Abstraction, Need for Design Automation on Higher Abstraction Levels, Essential issues in Synthesis. Architectural Models in Synthesis. Combinational Logic, Finite State Machines. Quality Measures: Area and Performance measures. Other Measures. **Section B** Design Description Language: HDLs, Hardware Specific Features, Formats, HDLs for DSP, Simulation Based HDLs, Modeling Guidelines for HDLs Design Representation and Transformations: Partitioning. Scheduling. Allocation. **Section C** Design Methodology for High-Level Synthesis: Generic Synthesis, System Synthesis, Chip Synthesis, Logic and Sequential Synthesis, Physical-Design Methodology, System and component Databases, Conceptualization Environment. High Level Synthesis ofASICs. High-Level Synthesis for Real-Time Digital Signal Processing.	This course expose students to the advanced HDL design techniques, methodology and industrial standard EDA tools in electronic design. This course also discusses the new ideas and techniques in high level synthesis, essential issues in synthesis, architectural model, and guidelines for HDL design. Students will be expected to explore design methodology for high level synthesis, chip synthesis and physical design methodology.	
			Text and Reference Books: 1. Daniel D. Gajski, Nikil D. Dutt, Alien C-H Wu, Steve Y-L Lin And High-Level Synthesis: Introduction to Chip	**Suggested E- resources:** 1. **High level Synthesis** by IIT Guwahati. https://nptel.ac.in/courses/117103125/4. 2. **Synthesis of Digital Systems** byDr.	

			and System Design, Kluwer Academic Publishers. 2. Wayne Wolf, High-Level VLSI Synthesis, Raul Camposano, Kluwer Academic Publishers. 3. David C. Ku, Giovanni de Micheli, High Level Synthesis of ASICs Under Timing and Synchronization Constraints, Kluwer Academic Publishers 4. Jan Vanhoof, Karl Van Rompaey, Ivo Bolsens, Gert Goossens, Hugo De Man, High-Level Synthesis for Real-Time Digital Signal Processing, The CATHEDRAL-11 Silicon Compiler, Kluwer Academic Publishers.	Preethi Ranjan Panda, Department of Computer Science & Engineering, Indian Institute of Technology, Delhi. https://nptel.ac.in/courses/106102181/7	
37	**VLSI 604R, VLSI Testing and Design for Testability**		**SECTION-A** Physical defects and their modeling; stuck at faults; Bridging Faults; Fault collapsing Fault Simulation Deductive, Parallel and Concurrent; Critical Path Tracing; Test Generation for Combinational Circuits : D-Algorithm, Boolean Difference, PODEM Random, Exhaustive and Weighted Random Test Pattern Generations Aliasing and its effect on Fault coverage **SECTION-B** PLA Testing: cross-point Fault Model, Test Generation, easily testable design, Memory testing: Permanent Intermittent and Pattern Sensitive Faults; Delay Faults and Hazards; Test Generation Techniques	The course attempts to expose the students to the most recent, yet fundamental, VLSI test principles in an effort to help them design better quality products that can be reliably manufactured in large quantity. The course explores the issue related to the physical defects, test generation technique for combinational and sequential circuits, controllability and obeservability and redundancy.	

			SECTION-C Test Generation for Sequential Circuits: Time Frame Expansion; Controllability and Obeservability Scan Design.Scan path and LSSD, boundary Scan, BILBO, Bounday Scan For Board Level Diagnosis. Concept of Redundancy, spatial redundancy. Time redundancy.		
			References: 1. M. Abramovici, M.A. Breuer and R.D. Friedman, Digital Systems Testing and Testable Design, Revised Edition, IEEE Press, 1995. 2. V. Agarwal and S. C. Seth, Test Generation for VLSI Chips, IEEE CS Press, 1989. 3. E. J. McCluskey, Logic Design Principles, Prentice Hall, 1986.	**Suggested E- resources:** 1. **Digital VLSI Testing** by Prof. Santanu Chattopadhyay Department of Electronics and Electrical Communication Engineering, IIT Kharagpur. https://onlinecourses.nptel.ac.in/noc17_ec02/preview. 2. **Testing and Verification of VLSI Circuits** by Prof. Virendra Singh IIT Mumbai. https://www.ee.iitb.ac.in/~viren/Courses/2012/EE709.htm	
38	**Advanced Electronic Packaging**			This course is designed to equip students with the required knowledge and concepts in mechanical, thermal, and reliability concern of modern electronic packaging. Emphasis is on IC packaging performance and its achievement through the proper material selection. The course will explore the multichip module, electrical autonomy IC assembly, challenges in the electronic packaging, and can recognize the various methods available and selection of appropriate packaging solution for particular applications.	
				Suggested e-resource: **1. An Introduction to Electronics Systems**	

				Packaging by IISC Bangalore. https://nptel.ac.in/courses/108108031/	
39	**Compound Semiconductor Technology**			This course provides students with the basic understanding of Non-Silicon MOSFET technology. The students should be able to use properties and trade-offs of compound semiconductors (GaAs, InAs, InP and InSb) for design of high performance MOSFETs. The students will be able to explain the challenges and power performance of strained III-V MOSFETs, the high k dielectric based MOSFETs. Students should also be able to discuss the Future Scaled CMOS and hybrid CMOS technology. **Suggested e-resources:** 1. **Nanoelectronics: Devicesand Materials**by Prof. K. N. Bhat Centre for Nano Science and Engineering. https://nptel.ac.in/courses/117108047/28. 2. **Compound Semiconductor Devices** by Prof. C. G. Fonstad, MIT, USA. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-772-compound-semiconductor-devices-spring-2003/lecture-notes/.	
40	**Digital Image Processing**			This course provides an introduction to basic concepts, methodologies and algorithms of digital image processing focusing on image analysis and image enhancement and restoration for easier interpretation of images. The course provides overview of digital image processing including visual perception, Image Digitization, Basic Transformations, Interpolation and Resampling, Image Interpolation, Image Transformation, Image Enhancement, Image Segmentation, Morphology, Object Representation and Description, object Recognition etc.The course focuses on to create an ability in	

				students to analyze a problem in this domain and identify the computing requirements appropriate for its solution; an ability to design, implement and evaluate a computer-based system, process, component or program to meet desired needs. **Suggested e-resource:** 1. **Digital Image Processing** by Prof .P. K. Biswas, IIT Kharagpur. https://nptel.ac.in/courses/117105079/	
41	**Organic Electronic Devices**			Organic electronic devices are quickly making their way into the commercial world, with innovative thin mobile devices, high-resolution displays, and photovoltaic cells. Purpose of the course is to learn about this highly promising technology, which is based on small molecules and polymers, and to discuss how these materials can be implemented successfully in established organic electronic modules. In this course students will gain the ability to tie molecular transport phenomena with macroscopic device response such that you will be well-prepared to analyse troubleshoot, and design the next generation of organic electronic materials and devices. **Suggested e-resources:** 1. **Organic Electronic Devices** by Dr. Bryan W. Boudouris, Purdue University. https://www.edx.org/course/organic-electronic-devices-purduex-nano515x	

Annexure V

Name of Programme: B.Sc.

Disciplinary Course-Physics

Programme Educational Objectives:

- To provide necessary knowledge and leadership skills for a successful professional career.
- To enhance learning and to adapt in a world of constantly evolving and innovative electronics technology.
- To develop the ability to collaborate with others to solve problems with creative thinking and effective communication.

Programme Outcomes: On completion of the B.Sc. the student will be able to

- Apply knowledge of mathematics and science.
- Understood the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
- Acquire the skills in handling scientific instruments, planning and performing in laboratory experiments.
- Think creatively (divergently and convergent) to propose novel ideas in explaining facts and figures or providing new solution to the problems. Realized how developments in any science subject helps in the development of other science subjects and vice-versa and how interdisciplinary approach helps in providing better solutions and new ideas for the sustainable developments.
- Realized that knowledge of subjects in other faculties such as humanities, performing arts, social sciences etc. can have greatly and effectively influence which inspires in evolving new scientific theories and inventions.
- Imbibed ethical, moral and social values in personal and social life leading to highly cultured and civilized personality. Developed various communication skills such as reading, listening, speaking, etc.
- Function with multidisciplinary teams.

Programme Scheme:

B.Sc. (Mathematics) Semester - I (December, 2019)
Disciplinary Course-Physics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
PHY 103	Electricity and Electronics	6	0	0	6	PHY 103	Electricity and Electronics	6	0	0	6
PHY 104L	Electronics Lab	0	0	4	2	PHY 104L	Electronics Lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - II (April/May, 2020)
Disciplinary Course-Physics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
PHY 107	Optics	6	0	0	6	PHY 107	Optics	6	0	0	6
PHY 107L	Optics Lab	0	0	4	2	PHY 107L	Optics Lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - III (December, 2020)
Disciplinary Course-Physics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
PHY 201	Mechanics	6	0	0	6	PHY 201	Mechanics	6	0	0	6
PHY 201L	Mechanics Lab	0	0	4	2	PHY 201L	Mechanics Lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - IV (April/May, 2021)
Disciplinary Course-Physics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
PHY 203	Statistical and Mathematical Physics	6	0	0	6		Thermodynamics, Statistical and Mathematical Physics	6	0	0	6
PHY 202L	Physics Lab	0	0	4	2		Physics Lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - V (December, 2021)
Disciplinary Course-Physics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
5.1	Quantum Atomic Molecular Physics						*Discipline Elective-I	6	0	0	6
	Atomic Physics Lab						* Discipline Elective-I Lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

B.Sc. (Mathematics) Semester - VI (April/May, 2022)
Disciplinary Course-Physics

Existing Scheme						Proposed Scheme					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
6.1	Nuclear and Solid State Physics						*Discipline Elective-II	6	0	0	6
	Nuclear and Solid State Physics Lab						* Discipline Elective-II lab	0	0	4	2
	Total	6	0	4	8		**Total**	6	0	4	8

Discipline Electives

S. No.	Course code	Name of Course	L	T	P	C
1.		Quantum Mechanics and Spectroscopy	6	0	0	6
2.		Quantum Mechanics and Spectroscopy Lab	0	0	4	2
3.		Advance Quantum Mechanics	6	0	0	6
4.		Advance Quantum Mechanics Lab	0	0	4	2
5.		Nuclear and Solid State Physics	6	0	0	6
6.		Nuclear and Solid State Physics Lab	0	0	4	2
7.		Advanced Semiconductor Devices	6	0	0	6
8.		Advanced Semiconductor Devices lab	0	0	4	2

Note: Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III, IV, V or VI with prior permission of respective heads, time table permitting.

L - Lecture hrs/week; T - Tutorial hrs/week;
P-Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C- Credit Points of the Course

Course Details:

S. N.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
1.	PHY103 Electricity and Electronics	After completion of this course, the students will be able to- • learn fundamentals and concepts of electricity and electronics • learn about the basic concepts of electronic and electrical circuit analysis techniques • apply the above motioned concept to design a range of electronic devices and circuit configurations.	**Recommended Books:** 1. Tayal D C (2005) Electricity and Magnetism, Himalaya Publishing House. 2. Saxena M. P. (1997) Electricity and Magnetism, College Book House. 3. Bhargava N N (2000), Basic Electronic, Tata McGraw Hill. 4. Mehta V.K.(2002), Principles of Electronics, S. Chand publisher. **References Books:** 1. Sadiku Mathew N.O.(2005) Elements of Electromagnetics, New Delhi, Oxford Univ. Press 2. Purcell, E. M. (1963). Berkeley physics course. *Electricity and magnetism*. 3. Millman, J., & Halkias, C. C. (1972). *Integrated electronics: analog and digital circuits and systems*. McGraw-Hill. **Suggested web-resources:** https://www.coursera.org/browse/physical-science-and-engineering/electrical-engineering https://www.edx.org/learn/electronics		**No change in the entire course** Update e-Resources

2.	PHY 104L	After completion of this course, the students will be able to- • demonstrate laboratory skills in physics laboratory and analyze the measurements to draw valid conclusions. • have oral and written scientific communication, and to think critically and work independently. • to understand principles of law of electricity magnetism.	1. Determine the energy gap using junction diode 2. Study the characteristics of junction diode and zener diode 3. Study the voltage regulation and ripple factor of half and full wave rectifier 4. Study the bridge rectifier with filters 5. Study the characteristics of PNP/NPN junction transistor 6. Study the characteristics of FET 7. Study a voltage multiplier circuit to generate high voltage DC from AC 8. Study the characteristics of optoelectronic devices (LED, Photodiode and Phototransistor) 9. Study the OPAMP in (i) inverting mod (ii) noninverting mod (iii) integrator (iv) differentiator 10. Study AND, OR, NOT, NOR and NAND logic gates and verify the truth tables ~~11. Study the voltage gain and frequency response of a double stage RC coupled transistor amplifier~~ ~~12. Study the characteristics of a thermistor~~	1. Determine the energy gap using junction diode 2. Study the characteristics of junction diode and zener diode 3. Study the voltage regulation and ripple factor of half and full wave rectifier 4. Study the bridge rectifier with filters 5. Study the characteristics of PNP/NPN junction transistor 6. Study the characteristics of FET 7. Study a voltage multiplier circuit to generate high voltage DC from AC 8. Study the characteristics of optoelectronic devices (LED, Photodiode and Phototransistor) 9. Study the OPAMP in (i) inverting mod (ii) noninverting mod (iii) integrator (iv) differentiator 10. Study AND, OR, NOT, NOR and NAND logic gates and verify the truth tables 11. Study of electromagnetic induction by oscillation of bar magnet. 12. Mutual induction by direct method. 13. Verification of Faraday's law *and Lenz's law*. 14. B-H Curve using Magnetometer. 15. To determine Self Inductance of a Coil by Anderson's Bridge using AC 16. To determine Self Inductance of a Coil by Rayleigh's Method. 17. Determination of mutual inductance of a pair of coils using BG.	50 % of the syllabus deals with electricity and electromagnetism so experiment no. 11 and 12 is removed from the existing list and 4 new experiment is introduced in proposed list.

3.	PHY 107 Optics	After completion of this course, the students will be able to- • appreciate the efficacy of Fourier transforms and their application to physical systems. • understand the role of the wave equation and appreciate the universal nature of wave motion in a range of physical systems • understand dispersion in waves and model dispersion using Fourier theory. • understand diffraction and imaging in terms of Fourier optics and gain physical and intuitive insight in a range of physics via the spatial Fourier Transform.	**Recommended Books:** 1. Khandelwal D.P. (1973), Text book of optics and Atomic Physics, Pub. Shivlal Darwal, Agra. 2. Lal B. & Subramanium (2006), Optics by Brij Lal and Subrahmanium, S. Chand Publication. 3. Ghatak, A., & Thyagarajan, K. (1998). *An introduction to fiber optics*. Cambridge university press. 4. Ghatak, A. K. (1971). An introduction to modern optics. *An introduction to modern optics., by Ghatak, AK. New York, NY (USA): McGraw-Hill.* **Reference Books:** 1. Ghatak, A. K. (2012). *Contemporary optics*. Springer Science & Business Media. 2. Hecht, J., & Long, L. (1993). *Understanding fiber optics* (Vol. 3). Prentice Hall. 3. Cherin, A. H., & Short, L. (1983). *An introduction to optical fibers* (p. 135). New York: McGraw-Hill. 4. Hecht E (2006) Optics, Pearson Education. 5. Ghatak, A. K., & Thyagarajan, K. (1989). *Optical electronics*. Cambridge University Press. **Suggested web-resources:** https://www.coursera.org/courses?query=optics https://swayam.gov.in/courses/4906-july-2018-modern-optics	**No change in the entire course** Update e-Resources

4.	PHY 107 L Optics Lab	After completion of this course, the students will be able to- • demonstrate laboratory skills in physics laboratory and analyze the measurements to draw valid conclusions. • have oral and written scientific communication, and to think critically and work independently. • to understand principles of Optics and wave nature of light.		**No change in the entire course**

5.	PHY 201 Mechanics	After completion of this course, the students will be able to- • demonstrate proficiency in mathematics and the mathematical concepts needed for a proper understanding of physics. • show that they have learned laboratory skills, enabling them to take measurements in a physics laboratory and analyze the measurements to draw valid conclusions. • have oral and written scientific communication, and think critically and work independently.	**Recommended Books:** 1. Saxena M. P. Rawat S S (2000) Mechanics, College Book House. 2. Saxena M. P. Rawat S S (1997) Oscillations and Waves, College Book House. 3. Mathur D. S. (2005) Mechanics, S. Chand publishing. 4. Satya Prakash (2007) Waves & Oscillations, Kedar Nath Ram Nath publishing. **Reference Books:** 1. Srivasatava P. K. (2006) Mechanics New Age International Publisher, Delhi. 2. Alonso, M., & Finn, E. J. (1967). *Fundamental university physics* (Vol. 2). Reading, MA: Addison-Wesley. 3. Purcell, E. M. (1963). Berkeley physics course. *Electricity and magnetism,UC Berkeley*. 4. French, A. P. (1971). *Vibrations and waves*. CRC press. **Suggested web-resources:** https://ocw.mit.edu/courses/physics/ https://academicearth.org/physics/ https://www.khanacademy.org/science/physics	**No change in the entire course** Update e-Resources

6.	PHY 201L Mechanics Lab	After completion of this course, the students will be able to- • demonstrate laboratory skills in physics laboratory and analyze the measurements to draw valid conclusions. • have oral and written scientific communication, and to think critically and work independently. • to understand principles of Newtonian mechanics, friction, and motion of bodies.		**No change in the entire course**

7.	PHY 203 ~~Statistical and Mathematical Physics~~ **New Proposed Title-** Thermodynamics, Statistical and Mathematical Physics	After completion of this course, the students will be able to- • understand the laws of thermodynamics in their various forms and explain their physical significance. • state the thermodynamic potentials and recognize the most appropriate potential for application to a particular problem. • derive and state the Boltzmann, Fermi-Dirac and Bose-Einstein distributions. • know the key links between thermodynamics and statistical physics and apply these to problems.	**Recommended Books:** 1. Zeemansky M.W. (1968) Heat and Thermodynamics, McGraw Hill, 5th ed. 2. Singhal, Agrawal Prakash (2007)Heat and Thermodynamics, Pragati Prakashan. 3. Kakani S. L. Hemraj C (1994) Mathematical Physics and Special Theory of Relativity College Book Centre, Jaipur. 4. Rajput B S. (2005), Mathematical Physics, Pragati Prakashan. **Reference Books:** 1. Reif, F. (2009). Fundamentals of statistical and thermal physics. Waveland Press. 2. Holman, J. P. (1974). Thermodynamics McGraw-Hill. New York. 3. Lokanathan, S., & Gambhir, R. S. (1991). Statistical and Thermal Physics: an Introduction. Prentice Hall. 4. French, A. P. (2017). Special relativity. CRC Press. 5. Arfken, G. B., & Weber, H. J. (1999). Mathematical methods for physicists, Elsevier. **Suggested web-resources:** https://cosmolearning.org/courses/thermal-statistical-physics/ https://ocw.mit.edu/courses/physics/8-333-statistical-mechanics-i-statistical-mechanics-of-particles-fall-2013/video-lectures/lecture-1-thermodynamics-part-1/ https://programsandcourses.anu.edu.au/course/PHYS2020	**No change in the entire course contents, but the title of the course has been changed** Update e-Resources

8.	PHY 202L	After completion of this course, the students will be able to- • demonstrate laboratory skills in physics laboratory and analyze the measurements to draw valid conclusions. • have oral and written scientific communication, and to think critically and work independently. • to understand principles of thermodynamic laws experimentally	1. Determine the mechanical equivalent of heat (J) by using Calendar and Barn's constant flow meter. 2. To Determine the thermal conductivity of bad conductor (samples may be Glass or Ply Wood or Cardboard) using Lee's disc method. 3. Determine the melting point of given material using platinum resistance thermometer. 4. Plot thermo emf Vs temperature graph and find the inversion temperature and neutral temperature 5. To determine the thermodynamic constant (C_p/C_v) using Clement and Desorme's method. ~~6. Study of the variation of total thermal radiation with temperature and verify the stefan's law.~~ 7. To determine the value of stefan's constant. 8. Verify certain laws of probability. ~~9. To study the RC transmission line.~~ ~~10. To study the LC transmission line~~. 11. To determine the resistance per unit length of Carey Fosters bridge and finds the resistance of a given wire (Unknown resistance).	1. Determine the mechanical equivalent of heat (J) by using Calendar and Barn's constant flow meter. 2. To Determine the thermal conductivity of bad conductor (samples may be Glass or Ply Wood or Cardboard) using Lee's disc method. 3. Determine the melting point of given material using platinum resistance thermometer. 4. Plot thermo emf Vs temperature graph and find the inversion temperature and neutral temperature 5. To determine the thermodynamic constant (C_p/C_v) using Clement and Desorme's method. 6. To verify the Stefan's law by electrical method. 7. To determine the value of stefan's constant. 8. Verify certain laws of probability. 9. To determine the resistance per unit length of Carey Fosters bridge and finds the resistance of a given wire (Unknown resistance). 10. Determination of the coefficient of linear thermal expansion (α) of the given sample. Compare and verification of (α_{copper})< (α_{brass})< ($\alpha_{aluminum}$). 11. To determine mechanical equivalent of heat (J) Joule's constant by electrical method. 12. Determine the resistance per unit length of bridge wire and then determine the temperature coefficient of Platinum resistance thermometer (PTR). **13.** To demonstrate Seebeck Effect with the help of Thermocouple module.	Experiment No. 6, 10, 11, 12 and 13 have been proposed to strengthen the laboratory practices. Expt. No. 9 and 10 in existing course have been removed due to unmatched with theory

9.	5.1 ~~Quantum Atomic Molecular Physics~~ Quantum Mechanics and Spectroscopy	After completion of this course, the students will be able to- • solve the Schrödinger equation for model systems of relevance within chemistry and physics • describe many-electron atoms with the independent particle model • describe the structure of the periodic system and the connections between the properties of the elements and their electron configurations • describe the bases behind interaction between light and matter and account for the most common spectroscopic methods for studies of molecules in the IR and UV/Vis areas	**Recommended Books:** 1. Kakani S. L., Hemrajni C. (1995) Elementary Quantum Mechanics and Spectroscopy, College Book Centre, Jaipur. 2. Singh K., Singh S. P. (2005) Elements of Quantum Mechanics, S. Chand. 3. Raj Kumar (1997), Atomic and Molecular Spectera, Kedar Nath Ram Nath publisher. 4. Rawat S. S. Singh Sardar (2000) Prarambhik Quantum Yantriki avam Spectroscopy, CBH publisher. 5. Kakani S. L. Hemraj C (1994) Mathematical Physics and Special Theory of Relativity College Book Centre, Jaipur. **Reference Books:** 1. Ghatak, A. K., & Lokanathan, S. (2004). Quantum mechanics: theory and applications. Macmillan. 2. Beiser, A. (1969). Perspectives of modern physics. McGraw-Hill series in fundamentals of physics, Tata McGraw-Hill. 3. White, H. E. (1934). Atomic Spectra. New York-London: McGraw-Hill, 15, 132. **Suggested web-resources:** https://swayam.gov.in/course/4250-quantum-chemistry-spectroscopy-photochemistry https://www.edx.org/course/quantum-mechanics-molecular-structures-utokyox-utokyo003x-1	**No change in the entire course contents, but the title of the course has been changed** Update e-Resources
10.	5.2 Atomic Physics Lab	After completion of this course, the students will be able to- • demonstrate measurements skills in a physics laboratory • analyze the measurement results to draw valid conclusions. • have oral and written scientific communication, and think critically and work independently.	1 Determine the value of Planck constant using Photo cell. 2 Determine the value of Planck constant using solar cell. 3 Study the absorption spectrum of Iodine Molecule. 4 Study the Franck Hertz experiment and determine the ionization potential of inert gas. 5 Study the hyperfine structure of spectral lines and Zeeman effect by constant deviation method 6 Determine the electrical charge (e/m) using Millikan's oil drop method. 7 Determine the specific charge (e/m) using Thomson method. 8 Determine the specific charge (e/m) using helical	1.Determine the value of Planck constant using Photo cell. 2.Determine the value of Planck constant using solar cell. 3.Study the absorption spectrum of Iodine Molecule. 4.Study the Franck Hertz experiment and determine the ionization potential of inert gas. 5.Study the hyperfine structure of spectral lines and Zeeman effect by constant deviation method 6.Determine the electrical charge (e/m) using Millikan's oil drop method. 7.Determine the specific charge (e/m) using Thomson method. 8.Determine the specific charge (e/m) using helical method. **9.To study the hydrogen spectrum and determination of Rydberg's constant.** **10. Verify the inverse square law using photocell.**	Experiment Nos. 9 to 14 have been proposed to strengthen the laboratory practices. Experiment Nos. 9 to 12 in existing course have been removed from the existing experiments list due to unmatched with the theory course in the relevant semester.

			method. ~~9 Determine ballistic constant using constant deflection method.~~ ~~10 Determine ballistic constant using condenser method.~~ ~~11 Determine unknown high resistance by leakage method.~~ ~~12 Determine the magnetic field using ballistic Galvanometer and search coil.~~	**11. Determine the value of Planck constant using LED.** **12. To determine the unknown inductance of the coil (L) using Anderson's bridge.** **13. To determine the unknown capacitance using Desauty's bridge** **14. To obtain lande-g factor by ESR method.** **To determine the workfunction of given metal by suitable method.**	
11.	Advanced Quantum Mechanics	After completion of this course, the students will be able to- • solve the Schrödinger equation for complex systems • describe the structure of the periodic system and the connections between the properties of the elements and their electron configurations • understand the effect of external parameters on the quantum systems		**Unit-1** Postulates of Quantum Mechanics, Planck's Quantum theory, Einstein's explanation, Compton Effect, Wave Particle Duality, de-Broglie waves, Electron Diffraction Experiment, Uncertainty Principle: Formulation and its applications, Bohr's principle of complementarity, Time dependent and time independent forms of Schrodinger's equation: need and justification **Unit-2** Wave Function, its physical significance and properties, Schrodinger and Born interpretation, Probability Current Density, eigenvalues and eigenfunctions, degeneracy, parity and orthogonality of eigenfunctions, expectation values of dynamical variables-position, momentum, energy, Ehrenfest Theorem, Time independent schrodinger equation and stationary state solution, particle in one dimensional box: eigenfunctions and eigenvalues **Unit-3** Discrete energy levels, generalization to three dimensions and degeneracy of levels, Potential step and rectangular potential barrier, Calculation of reflection and transmission coefficients, Alpha Decay, Square Well Potential Problem(attractive), Calculation of	

				transmission and reflection coefficients, Applications of Schrodinger Equation in Spherically symmetric systems: Rigid Rotator and Hydrogen Atom **Unit-4** Operators in quantum mechanics: Definition, Orthogonal Sets, Completeness, Eigen values and Eigenfunction, Operator Formalism, Commutation Algebra, Linear and Hermitian Operators, Commutativity and simultaneous eigenfunctions, Hilbert Space, Operators as matrix, Matrix form of wave equation, Schrodinger, Heisenberg and Interaction matrix representation, Dirac's Bra and Ket vectors, Direct Sum and product of Hilbert space, Co-ordinate and momentum representation **Unit-5** Approximation Methods: perturbation theory, motivation of approximation methods, Variational methods, WKB Approximation, Applications of Variational and WKB methods. Time dependent perturbation theory, Harmonic perturbation. **Recommended Books:** 1. Singh K., Singh S. P. (2005) Elements of Quantum Mechanics, S. Chand. 2. Ghatak, A. & Lokanathan S. (2001) Quantum Mechanics (McMillan India Ltd.) 3. Sakurai J. J. (2005) Modern Quantum Mechanics (Pearson Education) 4. Griffiths D. (2006) Introduction to Quantum Mechanics (Pearson Education) 5. Bjorken J. D. and S. D. Drell (1997) Relativistic Quantum Mechanics (McGraw Hill) 6. Greiner,W and Bromley D. A. (2003) Relativistic Quantum Mechanics (Springer)	

				Reference Books: 1. Ghatak, A. K., & Lokanathan, S. (2004). Quantum mechanics: theory and applications. Macmillan. 2. Beiser, A. (1969). Perspectives of modern physics. McGraw-Hill series in fundamentals of physics, Tata McGraw-Hill. 3. White, H. E. (1934). Atomic Spectra. New York-London: McGraw-Hill, 15, 132. **Suggested web-resources:** https://swayam.gov.in/course/4250-quantum-chemistry-spectroscopy-photochemistry https://www.edx.org/course/quantum-mechanics-molecular-structures-utokyox-utokyo003x-1	
12.	5.2 Advanced Quantum Mechanics Lab	After completion of this course, the students will be able to- • demonstrate measurements skills in a physics laboratory • analyze the measurement results to draw valid conclusions. • have oral and written scientific communication, and think critically and work independently.		1. Determine the specific charge (e/m) using Thomson method. 2. Determine the specific charge (e/m) using helical method. 3. Study the hyperfine structure of spectral lines and Zeeman effect by constant deviation method 4. Determine the electrical charge (e/m) using Millikan's oil drop method. 5. To study the hydrogen spectrum and determination of Rydberg's constant. 6. Verify the inverse square law using photocell. 7. Determine the value of Planck constant using Photo cell. 8. Determine the value of Planck constant using solar cell. 9. Study the absorption spectrum of Iodine Molecule. 10. Study the Franck Hertz experiment and determine the ionization potential of inert gas. 11. Determine the value of Planck constant using LED. 12. To determine the workfunction of given metal by suitable method.	

13.	6.1 Nuclear and Solid State Physics	After completion of this course, the students will be able to- • account for interatomic forces and bonds • have a basic knowledge of crystal systems and spatial symmetries • account for how crystalline materials are studied using diffraction, including concepts like form factor, structure factor, and scattering amplitude. • understand the concepts of nuclear physics • understand the elementary particles and their interactions	**Recommended Books:** 1. Tayal D C (1992) Nuclear physics, Himalya Pub. House, Bombay. 2. Kaplan, I. (1963). Nuclear physics, Oxford & IBH Pub. 3. Pillai S O. (2005), Solid State Physics, New Age International. 4. Singhal R. L. Alvi P. A. (2015) Solid State Physics, Kedarnath Ramnath, Meerut. **Reference Books:** 1. Singru, R. M. (1974). Introduction to experimental nuclear physics, Wiley Eastern Pvt. Ltd. 2. Ghoshal S. N. (2006) Nuclear Physics by S. N., S. Chand. 3. Kittel, C. (1976). Introduction to solid state physics (Vol. 8). New York: Wiley. **4.** Ashcroft, N. W., & Mermin, N. D. (1976). Solid state physics, Cornell University Saunders College Publishing. **Suggested web-resources:** https://swayam.gov.in/course/3817-solid-state-physics https://nptel.ac.in/courses/115105099/ https://ocw.mit.edu/courses/nuclear-engineering/	**No change in the entire course** Update e-Resources

14.	6.2 Nuclear and Solid State Physics Lab	After completion of this course, the students will be able to- • demonstrate measurements skills in a physics laboratory • analyze the measurement results to draw valid conclusions. • have oral and written scientific communication, and think critically and work independently. • to understand the laws of nuclear and solid state physics		**No change in the entire course**

15.	Advanced Semiconductor Devices	course, the students will be able to- • understand the mechanism of semiconductor devices • understand the applications of semiconductor devices in routine life • make advancement in these devices		**Unit-1** Energy Bands, direct and indirect semiconductors, effective mass, Intrinsic and Extrinsic semiconductors, Occupation Probability and carrier concentration, Temperature Dependence of carrier concentration, Fermi Level, Quasi Fermi Level, mobility and conductivity, Hall effect, four probe method of resistivity measurement **Unit-2** Generation and Recombination of Charges, Diffusion, Continuity Equation, Injected Minority charge carriers, potential variation within a graded semiconductor, Schottky Junction and Ohmic Contact, pn junction diode, Zener diode, Zener and avalanche breakdown, Tunnel diode, Semiconductor Photodiode and Light Emitting Diode **Unit-3** Avalanche Photodiode: Structure, Materials, Characteristics and device performance Bipolar Junction Transistor: Types, Current components, CB,CC,CE configuration, Ebers-Moll model of transistors. Concept of Load Line and Operating Point, Thermal stability of transistor, Fixed Bias, Emitter Bias, Voltage Divider Bias, Collector Feedback Configuration **Unit-4** Junction Field Effect transistor, depletion and enhancement type MOSFET, V-I characteristic, operation methods, FET biasing: Fixed, self and Voltage Divider Bias Four Layer Diode (p-n-p-n), SCR, Principle of operation, transistor analogy, methods of turning on and turning off (only reference), Gate characteristic, DIAC, TRIAC, light activated thyristor Unit-5 Operational Amplifier and its applications, inverting and non-inverting amplifiers, adder, integrator, differentiator,	

				wave-form generator, comparator, Schmitt trigger. **Recommended Books:** 1. Millaman J. and Halkias C. (1972) Integrated Electronics (McGraw Hill, New York), 2. Malvino L. (1999) Electronic Devices and circuits 3. Sterectman B. G. (1995) Solid State Electronic Devices and Integrated Circuits (Prentice Hall Inc.). 4. Sze S.M. (1999) Physics of Semiconductors Devices by (John Wiley & Sons). **Suggested e-resources:** **1.** https://nptel.ac.in/courses/115102014/ **2.** https://nptel.ac.in/courses/113106062/ **3.** https://nptel.ac.in/courses/117106091/	

16.	Advanced Semiconductor Devices LAB	After completion of this course, the students will be able to- • assess the validity of physical theories through the design and execution of an experiment, the analysis of uncertainties associated with the measurement of data and the interpretation of the data to draw valid scientific conclusions (lab skills). • connect a digital oscilloscope to a computer and record a signal with an appropriate sampling rate; • generate and interpret the power spectrum of the recorded data, use the tools, methodologies, language and conventions of physics to test and communicate ideas and explanations		1 To study the V-I characteristics of FET using discrete components on bread board. 2 To study the V-I characteristics of UJT. 3 To study the output and transfer characteristics of FET. 4 To study the input and output characteristics of BJT. 5 To study the V-I characteristics of DIAC. 6 To study the V-I characteristics of TRIAC. 7 To study the V-I characteristics of SCR. 8 To study the characteristics of optocoupler and draw its frequency response. 9 To study the V-I characteristics of Photodiode. 10 To study the V-I characteristics of p-n junction diode using discrete components on bread board. 11 To study the V-I characteristics of pnp or npn transistor using discrete components on bread board.	

ANNEXURE-VII A

Name of Programme: M. Sc. (Physics)

Programme Educational Objectives

Among various science subjects, Physics is a natural science which deals with the behavior of matter, energy and the natural laws. The core theories of Physics are: Classical Mechanics, Electromagnetism, Thermodynamics and Statistical Mechanics, Quantum Mechanics and Relativity. There are many more branches of Physics like including astronomy, biophysics, atmospheric physics, nuclear physics etc. Therefore, Physics plays a key role in the future progress of humankind either in education or research in the world because of its characteristics features.

Keeping in views the entire scientific development of the student through covering almost all the courses, the M.Sc. (Physics) programme has been designed. The present programme aims to train the students to acquire high level theoretical and experimental knowledge in Physics through learning the designed studies with high quality and significance. However, the main objectives of the programmes are as follows:

- To provide the fundamental concepts of nature in terms of physics with their utilizations
- To produce MSc students who are very knowledgeable and theoretically sound and are able to apply these for the analysis and solution of problems where these leads to new or substantially improved insights and performances.
- To provide the knowledge of various new techniques by which the students can lead the cutting edge technologies
- To encourage research and development activities
- To prepare the competent physicists at national and international level
- To produce MSc students with high integrity having social values and who are ethically professional
- To produce MSc students who can think critically and creatively thus capable of generating and developing new knowledge, products, materials or methods for the benefits of mankind.
- To produce MSc students with excellent communication skills, capable of communicating effectively in various context, thus sharing new knowledge with other researchers from other institutions, universities and also industrialists
- To develop gender –neutral attitudes and practices; respect for all races, nations, religions, culture, languages and traditions
- To produce MSc students who can adapt to changes in environment and practice lifelong learning
- To provide the ideas about pollution control and environment sustainability through exemplary education

Programme Outcomes

PO1: Physics Knowledge: Possess fundamental knowledge of various core courses of physics to solve complex scientific problems of the society. Also, the students will be able to apply theoretical knowledge of principles and concepts of Physics to practical problems

PO2: Planning Abilities-Ability to demonstrate efficient planning including time management, resource management and organization skills.

PO3: Expert of Advanced Tool: Expertise in new and advanced techniques like photo-sepectrometer, XRD, FESEM, Raman, DSC etc. through project component of the programme.

PO4: Problem analysis ability-Ability to apply physics principles alongwith other scientific conceptual attitude to analyze the problems related to society and to show the caliber for finding the solution.

PO5: Leadership Skills- ability to have leadership skills with high regard for ethical values and social responsivities through learning of time management and team work skill.

PO6: Professional Identity- Possess ability to prove professional identity in any institution and industry at national and international level

PO9 7: Physics and society-Ability to explain the understanding of impact of physics study on the society including pollution, environment, health and ecosystem. In addition, the students will be able to propagate their knowledge to address problems of social relevance such as energy, and environment through their specific electives.

PO8: Communication-Possess effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate the role of physics to address environmental issues.

PO9: environment and sustainability- Understanding about environment sustainability and pollution control through project and laboratory practices

PO10: Life-long learning- Possess the knowledge of current issues and ability to engage in life-long learning

Master of Science (Physics)

Programme Scheme:

Semester (I):

Existing						Proposed					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
CS 416	Computer Programming	4	0	0	4	CS 416	Computer Programming	4	0	0	4
ELE 406	Principle of Digital Electronics	4	0	0	4	ELE 406	Principle of Digital Electronics	4	0	0	4
PHY 403	Classical Mechanics	4	0	0	4		Classical Mechanics	4	0	0	4
PHY 404	Mathematical Physics	4	0	0	4		Mathematical Physics	4	0	0	4
PHY 406	Quantum Mechanics-I	4	0	0	4	PHY 406	Quantum Mechanics-I	4	0	0	4
CS 416L	Computer Programming Lab	0	0	8	4	CS 416L	Computer Programming Lab	0	0	8	4
ELE 406L	Principle of Digital Electronics Lab	0	0	4	2	ELE 406L	Principle of Digital Electronics Lab	0	0	4	2
	Total:	20	0	12	26		**Total:**	20	0	12	26

Semester (II):

Existing						Proposed					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
CS 414	Computer oriented numerical and statistical methods	4	0	0	4	CS 414	Computer oriented numerical and statistical methods	4	0	0	4
PHY 401	Atomic and Molecular Physics	4	0	0	4	PHY 401	Atomic and Molecular Physics	4	0	0	4
PHY 402	Classical Electrodynamics-I	4	0	0	4		Classical Electrodynamics-I	4	0	0	4
PHY 407	Quantum Mechanics-II	4	0	0	4		Quantum Mechanics-II	4	0	0	4
PHY 408	Statistical Mechanics	4	0	0	4	PHY 408	Statistical Mechanics	4	0	0	4
TSKL 403	Communication Skills	2	0	0	2		Communication Skills	2	0	0	2
CS 414L	Computer oriented numerical and statistical methods Lab	0	0	4	2	CS 414L	Computer oriented numerical and statistical methods Lab	0	0	4	2
PHY 405L	Physics Lab-I	0	0	8	4	PHY 405L	Physics Lab-I	0	0	8	4
	Total:	22	0	12	28		**Total:**	22	0	12	28

Semester (III):

Existing

Course Code	Course Name	L	T	P	C
PHY 530	Solid State Physics	4	0	0	4
PHY 504	Classical Electrodynamics-II	4	0	0	4
PHY 516	Nuclear Physics-I	4	0	0	4
PHY 520	Physics of Laser and Laser Applications	4	0	0	4
PHY 518L	Physics Lab-II	0	0	8	4
	Elective-I	4	0	0	4
PHY 527S	Seminar	0	0	2	1
	Total:	20	0	14	27

Proposed

Semester - III

Course Code	Course Name	L	T	P	C
PHY 530	Solid State Physics	4	0	0	4
PHY 504	Classical Electrodynamics-II	4	0	0	4
PHY 516	Nuclear Physics-I	4	0	0	4
	Physics of Laser and Laser Applications	4	0	0	4
	Physics Lab-II	0	0	8	4
	Discipline Elective	4	0	0	4
	Reading Elective	0	0	0	2
PHY 527S	Seminar	0	0	2	1
	Semester Wise Total:	**20**	**0**	**10**	**27**

Semester (IV):

Existing

Course Code	Course Name	L	T	P	C
PHY 529	Solid State Electronics Devices	4	0	0	4
ELE 307	Microwave Electronics	4	0	0	4
PHY 517	Nuclear Physics-II	4	0	0	4
PHY 519L	Physics Lab-III	0	0	8	4
	Elective-II	4	0	0	4
PHY 525P	Project	0	0	8	4
	Total:	**16**	**0**	**16**	**24**

Proposed

Semester - IV

Course Code	Course Name	L	T	P	C
PHY 529	Solid State Electronics Devices	4	0	0	4
ELE 307	Microwave Electronics	4	0	0	4
PHY 517	Nuclear Physics-II	4	0	0	4
PHY 525P	Project	0	0	8	4
	Physics Lab-III	0	0	8	4
	Open Elective	4	0	0	4
Semester Wise Total:		16	0	16	24

Discipline Electives					**Reading Electives**				
Fibre Optics Communication	4	0	0	4	Optical materials and Devices	0	0	0	2
Physics of Nano-structure & Nanotechnology-I	4	0	0	4	Solar Energy: photovoltaic systems	0	0	0	2
Plasma Physics-I	4	0	0	4	Introduction to photonics	0	0	0	2
High Energy Physics-I	4	0	0	4					
Nonlinear Physics-I	4	0	0	4					
Condensed Matter Physics-I	4	0	0	4					
Science and Technology of Solar Hydrogen and other Renewable Energies	4	0	0	4					
Bio Physics-I	4	0	0	4					
Analog and Digital Communication	4	0	0	4					
Physics of Nano-structure & Nanotechnology-II	4	0	0	4					
Plasma Physics-II	4	0	0	4					
High Energy Physics-II	4	0	0	4					
Nonlinear Physics-II	4	0	0	4					
Condensed Matter Physics-II	4	0	0	4					
Solar Energy: Principles of Solar Thermal Devices	4	0	0	4					
Bio Physics-II	4	0	0	4					

Annexure-VIIIA

Name of Programme: M. Tech. (Nanotechnology)

Programme Educational Objectives

Banasthali Vidyapith has made a significant contribution in the technology education by introducing the M.Tech. (Nanotechnology) programme. Nanotechnology is not being considered simply a technology like other technologies which are confined almost in a limited area. In fact, the nanotechnology leads to a mission through which the whole country can be promoted in terms of sciences and technology. Keeping in view such a mission, The M. Tech. (Nanotechnology) programme has been designed by the department of Physics. Actually, M. Tech. (Nanotechnology) is an umbrella programme for capacity building which envisages the overall development of this field of research in the country and to tap some of its applied potential for nation's development.

Keeping in views the entire scientific and technological development of the student through covering almost all the courses, the M. Tech. (Nanotechnology) programme has been designed. The present programme aims to train the students to acquire high level theoretical and experimental knowledge in the direction of technology through learning the designed courses with high quality and significance. However, the main objectives of the programmes are as follows:

- To prepare the students to outshine in academics and research in different motifs of Nanoscience and Nanotechnology.
- To train the students with good theoretical and practical knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real life problems.
- To provide the knowledge of various new techniques by which the students can lead the cutting edge technologies
- To encourage research and development activities
- To prepare the competent technologists at national and international level
- To provide students with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career
- To produce the students who can think critically and creatively thus capable of generating and developing new knowledge, products, materials or methods for the benefits of mankind.
- To prepare the students with excellent communication skills, capable of communicating effectively in various context, thus sharing new knowledge with other researchers from other institutions, universities and also industrialists
- To develop gender –neutral attitudes and practices; respect for all races, nations, religions, culture, languages and traditions
- To coach students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate nanotechnology to address environmental issues.
- To provide the ideas about environment sustainability and pollution control through exemplary and practical educations

Programme Outcomes

PO1: Knowledge about Technology: Able to apply knowledge and skills to solve complex technical problems which calls for insight into the latest technologies and best engineering practices including behavioral, social, and manufacturing practices.

PO2: Planning Abilities-Ability to demonstrate efficient planning including time management, resource management and organization skills

PO3: Problem analysis ability-Ability to apply scientific attitude to analyze the society problems and to apply information systematically for the solution

PO4: Modern Tool usage: Ability to handle new techniques and advanced tools like XRD, FESEM etc, which derive the nanosciences and nanotechnology

PO5: Leadership Skills- ability to have leadership skills with high regard for ethical values and social responsivities through the management related courses.

PO6: Professional Identity- able to show professional identity as competent technologists at national and international level

PO9 7: Technology and society-Ability to show the understanding of impact of nanomaterials on the society including environment, health and ecosystem. On the other side, the Graduates will be able to propagate their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.

PO8: Communication-Possess effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate nanotechnology to address environmental issues.

PO9: environment and sustainability- Understanding about environment sustainability and pollution control through laboratory practices

PO10: Life-long learning- Possess the knowledge of contemporary issues and ability to engage in life-long learning

M.Tech (Nanotechnology)

Programme Scheme:

Semester (I):

Existing						Proposed					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 506	Nano-Photonics & Optoelectronics	4	0	0	4		Nano-Photonics & Optoelectronics	4	0	0	4
PHY 502	Advanced Synthesis Processes and Devices	4	0	0	4	PHY 502	Advanced Synthesis Processes and Devices	4	0	0	4
PHY 508	Fundamentals of Nano-sciences and Nano-technology	4	0	0	4	PHY 508	Fundamentals of Nano-sciences and Nano-technology	4	0	0	4
PHY 511	Introduction to Materials Science	4	0	0	4	PHY 511	Introduction to Materials Science	4	0	0	4
PHY 531	Surface, Interface and Thin films	4	0	0	4	PHY 531	Surface, Interface and Thin films	4	0	0	4
NANO 502L	Simulation Lab-I	0	0	6	3		Simulation Lab-I	0	0	6	3
PHY 512L	Nano Fabrication and Characterization Lab-I	0	0	6	3	PHY 512L	Nano Fabrication and Characterization Lab-I	0	0	6	3
	Total:	20	0	12	26		**Total:**	20	0	12	26

Semester (II):

Existing						Proposed					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
ELE 501	Advanced Nano-electronics	4	0	0	4	ELE 501	Advanced Nano-electronics	4	0	0	4
MATH 514	Mathematical Modeling and Simulation	4	0	0	4	MATH 514	Mathematical Modeling and Simulation	4	0	0	4
NANO 501	Quantum Computations and Information Processing	4	0	0	4	NANO 501	Quantum Computations and Information Processing	4	0	0	4
PHY 501	Advanced Characterization Techniques	4	0	0	4	PHY 501	Advanced Characterization Techniques	4	0	0	4
NANO 503L	Simulation Lab-II	0	0	6	3		Simulation Lab-II	0	0	6	3
PHY 513L	Nano Fabrication and Characterization Lab-II	0	0	6	3	PHY 513L	Nano Fabrication and Characterization Lab-II	0	0	6	3
	Elective	4	0	0	4		Discipline Elective	4	0	0	4
	Total:	20	0	12	26		**Total:**	20	0	12	26

Discipline Electives	**L**	**T**	**P**	**C**
Nano-Engineering of Biological Systems	4	0	0	4
Organic and Polymer Technology	4	0	0	4
MEMS and NEMS Technology	4	0	0	4

Semester (III):

Existing						Proposed					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
	Reading Elective-I	0	0	4	2	PHY 601P	Project (Part-I)	0	0	48	24
PHY 601P	Project (Part-I)	0	0	48	24		Reading Elective-I	0	0	4	2
	Total:	0	0	52	26		**Total:**	0	0	52	26

Semester (IV):

Existing						Proposed					
Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
PHY 601P	Project (Part-I)	0	0	48	24	PHY 601P	Project (Part-I)	0	0	48	24
	Reading Elective-II	0	0	4	2		Reading Elective-II	0	0	4	2
	Total:	0	0	52	26		**Total:**	0	0	52	26

Reading Electives				
Nanotechnology in Healthcare and Environment	0	0	4	2
Development of Nanotechnology: A Global Aspect	0	0	4	2
Nanotechnology and Society	0	0	4	2
Tissue Engineering	0	0	4	2
Nano-Catalysis	0	0	4	2
RF and MMIC Design Reading	0	0	4	2

Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III, IV, with prior permission of respective heads, time table permiting.

Annexure VIII

Name of Programme: M.Tech. (Nanotechnology)

Course Details:

S. N.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
1.	ELE 506 Nano-Photonics & Optoelectronics	After completion of this course, the student will be able to- • understand the fundamental operating principles of photodevices • analyse LED and heterojunction laser materials selection and design • understand fundamentals of organic electronics and liquid crystal displays • get an overview of photonic systems	SECTION-A III-V semiconductor quantum wells, Quantum Dots, Nonlinear Optical Properties, Quantum Confined Stark effect, Dielectric confinement effect, Superlattices, Core shell Quantum Dots,Quantum Dot Quantum wells, Quantum confined structures as lasing media ~~Photonic Crystals, 1D,2D,3D photonic structures, Features of photonic crystals, Microcavity effect Methods of Fabrication, Photonic crystal optical circuitry Nonlinear Photonic crystals, Photonic Crystal Fibre, Photonic Crystal Sensor~~ SECTION-B Introduction to Lasers, Guided Waves,Gain in two level lasing medium, Lasing Condition and Gain in semiconductors, Selective Amplification and Coherence, Threshold condition for lasing, Lineshape function and line broadening mechanisms, Lasing threshold in two level system, LED: Basics, Choice of Materials, Light Output from LED, Semiconductor Lasers: Basic principles, Heterojunction Lasers: Energy Band diagram and Power output, Quantum Well and Quantum Dot lasers, Surface emitting lasers, Unipolar Devices, Quantum Cascade laser:	SECTION-A III-V semiconductors; Absorption in Semiconductors: Indirect Intrinsic transitions, Exciton absorption, Donor acceptor and Impurity Band Absorption; Effect of electric field on absorption: Franz Keldysh and Stark effect; Quantum confinement; Quantum Dots; Quantum wells; Absorption in Quantum Wells and Quantum Confined Stark effect; Radiation in Semiconductors: Relation between absorption and emission spectra, Near Bandgap radiative transitions, Deep-level transitions, Auger recombination; Dielectric confinement effect; Superlattices; Core shell Quantum Dots; Quantum confined structures as lasing media SECTION-B Introduction to Lasers; Gain in two level lasing medium; Lasing Condition and Gain in semiconductors; Selective Amplification and Coherence; Threshold condition for lasing; Lineshape function:Line broadening mechanisms: Natural Broadening, Collision Broadening, Doppler Broadening; Semiconductor Lasers: Basic principles; Heterojunction Lasers: Energy Band diagram and Power output; Quantum Well and Quantum Dot lasers; Multiple Quantum Well laser; Quantum Cascade laser:	Defining the topics to be studied in a clear form. Updating the course: Photonic Crystals moved to Section-C Defining the topics to be studied in a clear form Updating the course: portion on LED is deleted as not relevant.

			Structure and Principle of Operation SECTION-C ~~Photodiodes, Avalanche Photodiodes, Structure, Materials, Characteristics, Device performance, Infrared Quantum detectors, QWIPs, Operation Principles, design and material choices, Quantum dot Infrared Photodetectors, Extending QWIPs into shorter and longer wavelengths~~	Structure and Principle of Operation SECTION-C Photonic Crystals: 1D,2D,3D Photonic crystals, Photonic Bandgap and defects in photonic crystals, Features of photonic crystals, Optical microcavites, Methods of Fabrication, Nonlinear Photonic crystals, Photonic Crystal Fibre, Photonic Crystal Sensor; Surface Plasmons: Drude–Sommerfeld theory,Surface plasmon polaritons at plane interfaces, Properties of surface plasmon polaritons, Surface plasmon sensors, Surface plasmons in nano-optics, Plasmons supported by wires and particles **Recommended Books** 1. Bhattacharya P. (2002) Semiconductor Optoelectronic Devices (Prentice Hall India, IInd edition) 2. Prasad P. N. (2004) Nanophotonics (Wiley Interscience, USA). 3. Silvfast W.T. (1998) Laser Fundamentals by, (Cambridge University Press, UK) 4. Ghatak A, Thyagarajan, K (2010) Lasers, Fundamentals and applications (Springer Science+Business Media, USA) 5. Novotny L., Hecht B. (2006) Principles of Nano-Optics (Cambridge University Press, UK) **Suggested e-Resources:** NPTEL : Semiconductor optoelectronics https://nptel.ac.in/courses/115102103/ NPTEL : Nanophotonics https://nptel.ac.in/courses/118106021/1	1. Photonic Crystals moved from Section A to Section C. 2. Added topic on surface plasmons. 3. Deleted section on photodetectors as not relevant. Update e-Resources

2.	PHY 502 Advanced Synthesis Processes and Devices	After completion of this course, the students will be able to- • have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical synthesis processes. • have skills in problem solving, critical thinking and analytical reasoning as applied to scientific problems. • communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large. • explore new areas of research in both chemistry and allied fields of science and technology.	**Recommended Books** 1. Gabor L. Hornyak, Dutta J. Tibbals H.F., Rao A .(2008) Introduction to Nanoscience (CRC Press) 2. Vajtai, R. (Ed.). (2013). Springer handbook of nanomaterials. Springer Science & Business Media. 3. Henini, M. (Ed.). (2012). Molecular beam epitaxy: from research to mass production. Newnes. 4. Jackson, M. J. (Ed.). (2005). Microfabrication and nanomanufacturing. CRC press.. 5. Neamen, D. A. (2012). Semiconductor physics and devices: basic principles. New York, NY: McGraw-Hill,. 6. Manasreh, O. (2011). Introduction to nanomaterials and devices. John Wiley & Sons. **Suggested –e-resources** https://nptel.ac.in/courses/117106109/1 https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-152j-micro-nano-processing-technology-fall-2005/lecture-notes/cvd.pdf	**No change in entire course** **Update e-resources**
3.	PHY 508 Fundamentals of Nano-sciences and Nano-technology	After completion of this course, the students will be able to- • have knowledge of the general principles of physics, chemistry, electronics and biology	**Recommended Books** 1. Sulabha, K., & Kulkarni, K. (2007). Nanotechnology: principles and practices. 2. Guozhong, C. (2004). *Nanostructures and Nanomaterials: synthesis, properties and applications*. World scientific..	**No change in entire course** Update e-resources

		that play a role on the nanometer scale • have insight into the materials, fabrication and other experimental techniques that can be used on the nanoscale, as well as their limitations • understand of the formation of complex macro systems which are unique in their operations and possess new functionalities • have in-depth knowledge of at least one specialisation area within the field of nanoscience and nanotechnology	3. Köhler, M., & Fritzsche, W. (2008). *Nanotechnology: an introduction to nanostructuring techniques*. John Wiley & Sons.. 4. Roduner, E. (2015). *Nanoscopic materials: Size-dependent phenomena and growth principles*. Royal Society of Chemistry. **Suggested –e- resources** https://ocw.mit.edu/search/ocwsearch.htm?q=quantum%20dots https://nptel.ac.in/courses/103103026/8	
4.	PHY 511 Introduction to Materials Science	After completion of this course, the students will be able to- • apply knowledge of mathematics, science, and engineering to solve problems related to materials science and engineering. • design new nanomaterials, as well as characterize the new material.	**Recommended Books** 1. Callister, W. D., & Rethwisch, D. G. (2007). *Materials science and engineering: an introduction* (Vol. 7, pp. 665-715). New York: John wiley & sons. 2. Jones, D. R., & Ashby, M. F. (2012). *Engineering materials 2: an introduction to microstructures and processing*. Butterworth-Heinemann. **Suggested –e resources** https://ocw.mit.edu/courses/materials-science-and-engineering/3-012-fundamentals-of-materials-science-fall-2005/lecture-notes/lec17b.pdf https://nptel.ac.in/courses/112104039/53	**No change in entire course** Update e-resources

		• collaborate effectively on multidisciplinary teams. • communicate effectively in written and oral formats.		
5.	PHY 531 Surface, Interface and Thin films	After completion of this course, the students will be able to- • understand and describe properties of free liquid surfaces, such as surface tension, capillarity, wetting and spreading. • understand and describe electrical phenomena at surfaces, such as surface charge, surface potential, the electrical double layer, and basic electrochemical concepts. • describe the phase behaviour and aggregation of amphiphiles in solution and at interfaces. • desribe intermolecular forces, forces acting between molecules and	**Recommended Books** 1. Prutton M. (1994) Introduction to surface science, (Cambridge University Press) 2. Daillant, J., & Gibaud, A. (Eds.). (2008). *X-ray and neutron reflectivity: principles and applications* (Vol. 770). Springer 3. Delchar, T. A. (1993). *Vacuum physics and techniques*. Chapman and Hall.. **Suggested –e resources** https://nptel.ac.in/courses/112101004/downloads/(36-8-1)%20NPTEL%20-%20Vacuum%20Technology.pdf https://ocw.mit.edu/search/ocwsearch.htm?q=stm	**No change in entire course** Update e-resources

		surfaces, and surface forces.			
6.	NANO 502L Simulation Lab-I	After completion of this course, the students will be able to- • learn programming language, • use various dynamic and static libraries and few package on simulations related to nano-materials • understand various mechanism at nano-scale through simulations	~~To perform various experiments Atomistix Toolkit - Virtual NanoLab (ATK-VNL) simulation package is used. ATK-VNL produces very fast and reliable simulation results for various 1,2 and 3 dimensional nano-structures and nano-devices which will rather requires a very large and expansive laboratory at the experimental level. ATK-VNL helps students to understand the electronic, optical, thermal, mechanical and other properties of various nano-structures and materials at the atomic level.~~ **Simulation Lab-I** 1. ~~To calculate ionisation energy and electron affinity of benzene molecule in isolated (gas phase) and in SET environment.~~ 2. ~~To calculate binding energy of armchair graphene nano-ribbons.~~ 3. ~~To Calculate the band structure of pristine and Cu edge terminated armchair graphene nano-ribbons~~ 4. ~~To analyse Band structure of Cu edge doped armchair graphene nano-ribbons.~~ 5. ~~To calculate binding energy of zigzag graphene nano-ribbons.~~ 6. ~~To draw band structure of pristine and Cu terminated zigzag graphene nano-ribbons.~~ 7. ~~To draw band structure of pristine and Cu edge doped zigzag graphene nano-ribbons.~~ 8. ~~To calculate and analyse Density of states of a molecule based nano device.~~ 9. ~~To study molecular projected self-consistent Hamiltonian of a molecule based nano-device.~~ ~~To study HOMO, LUMO energy levels for a single molecule junction.~~	Introduction to Programming, problem analysis and algorithms. One programming language (C++, Python, Fortran, Java), Programming Software: Mathematica, MATLAB,Visualisation packages. 1. Use of standard library functions. 2. Problems based on do, while, for loops. 3. Problems based on array, data type, data analysis. 4. Sorting of numbers and one dimensional array searching. 5. Problems based on pointer, parameter passing in function. Recursion 6. Problems based on object oriented programming. Classes, Modules, Subroutines. 7. Reading writing from/in files. 8. Use of dynamic and static libraries. Command line arguments and shell scripting. Introduction to some Open source simulation tools that are used to model nanostructure at the levels of classical and quantum mechanics.	Knowledge of Software programming tools and programming language is necessary of any scientific training today. To reduce the dependency on proprietary software and enhance conceptual understanding of computational tools we need to learn various tools. A single software can not fulfil are the requirements.
7.	PHY 512L	After completion of this			

	Nano Fabrication and Characterization Lab-I	course, the students will be able to- • synthesize the nano-materials • characterize the synthesized materials using several advanced characterizing tools • seek potential of the materials for several industrial technological applications.		**No change in entire course**
8.	ELE 501 Advanced Nano-electronics	After completion of this course, the students will be able to- • cope up with certain nanoelectronic systems and building blocks such as: low-dimensional semiconductors, heterostructures, carbon nanotubes, quantum dots, nanowires etc. • set up and solve the Schrödinger equation for diferent types of potentials in one dimension as well as in 2 or 3 dimensions for specific cases. • use matrix methods for solving transport problems such as	**Recommended Books** 1. Hu, C. C. (2011). Modern Semiconductor Devices for Integrated Circuits. *Part I: Electrons and holes in a semiconductor*. 2. Taur, Y., & Ning, T. H. (2013). *Fundamentals of modern VLSI devices*. Cambridge university press. 3. Heinzel, T. (2008). *Mesoscopic electronics in solid state nanostructures*. John Wiley & Sons. 4. Waser, R. (Ed.). (2012). *Nanoelectronics and information technology*. John Wiley & Sons.. 5. Lundstrom, M., & Guo, J. (2006). *Nanoscale transistors: device physics, modeling and simulation*. Springer Science & Business Media. 6. Hanson, G. W. (2008). *Fundamentals of nanoelectronics*. Upper Saddle River: Pearson/Prentice Hall. **Reference Books:** 1. Heikkilä, T. T. (2013). *The physics of nanoelectronics: transport and fluctuation phenomena at low temperatures* (Vol. 21). Oxford University Press. 2. Park, B. G., Hwang, S. W., & Park, Y. J. (2012).*Nanoelectronic devices*. CRC Press. 3. Mitin, V. V., Kochelap, V. A., & Stroscio, M. A. (2008). Introduction to nanoelectronics. *Science, Nanotechnology, Engineering, and Applications (Cambridge Univ. press, Cambridge, 2008)*. 4. Chang, C. Y. (2000). *ULSI devices*. John Wiley & Sons. 5. Datta, S. (1997). *Electronic transport in mesoscopic systems*. Cambridge university press.	**No change in entire course** Update e-resources

		tunneling, resonant tunneling and know the concept of quantized conductance. • familiarize with searching for scientific information in their subject area, practice report writing and presenting their project in a seminar	**Suggested –e resources** https://nptel.ac.in/courses/113104004/ https://nptel.ac.in/courses/113104004/29	
9.	MATH 514 Mathematical Modeling and Simulation	After completion of this course, the students will be able to- • characterize engineering systems in terms of their essential elements, purpose, parameters, constraints, performance requirements, sub-systems, interconnections and environmental context. • model and solve the relationship between theoretical, mathematical, and computational modelling for predicting and optimizing performance and objective. • develop solutions and	**Recommended Books** 1. Chapra, S. C., & Canale, R. P. (2010). *Numerical methods for engineers*. Boston: McGraw-Hill Higher Education,. 2. Frenkel, D., & Smit, B. (2001). *Understanding molecular simulation: from algorithms to applications* (Vol. 1). Elsevier. 3. Ohno, K., Esfarjani, K., & Kawazoe, Y. (2018). *Computational materials science: from ab initio to Monte Carlo methods*. Springer.. **Suggested –e resources** https://nptel.ac.in/courses/103106119/ https://ocw.mit.edu/search/ocwsearch.htm?q=ab%20initio	**No change in entire course** Update e-resources

		extract results from the information generated in the context of the engineering domain to assist engineering decision making. • interpret the model and apply the results to resolve critical issues in a real world environment.			
10.	PHY 501 Advanced Characterization Techniques	After completion of this course, the students will be able to- • understand basic principles of the techniques presented in the course, their advantages and limitations. Furthermore, the student should understand the requirements for samples suitable for each technique. • perform simple and routine operations on the experimental setups.	**Recommended Books** 1. Ajayan, P. M., Schadler, L. S., & Braun, P. V. (2006).*Nanocomposite science and technology*. John Wiley & Sons. 2. Wang Z.L (2000) Characterization of nanophase materials – (Wiley-VCH, New York). 3. Rao, C. N. R., Müller, A., & Cheetham, A. K. (Eds.). (2006).*The chemistry of nanomaterials: synthesis, properties and applications*. John Wiley & Sons. 4. Cullity, B. D. (1978). Elements of X-ray Diffraction. 5. Rose, R.M., Shepard L.A., and. Wulff, (1966) The Structure and Properties of Materials (Wiley Eastern Ltd.) **Suggested –web resources** https://nptel.ac.in/courses/117106109/1 https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-152j-micro-nano-processing-technology-fall-2005/lecture-notes/cvd.pdf		**No change in entire course** Update e-Resources
11.	NANO 503L Simulation Lab-I	After completion of this course, the students will be able to-	~~To perform various experiments Atomistix Toolkit - Virtual NanoLab (ATK-VNL) simulation package is used. ATK-VNL produces very fast and reliable~~	**Learning coding programs in any one of the languages like Python, C++, Fortran, Mathematica etc.**	Knowledge of Software programming tools and programming language is necessary of any

		• write computer codes for scientific real problems using various numerical and simulation methods. • have command over the numerical analysis	~~simulation results for various 1,2 and 3 dimensional nano-structures and nano-devices which will rather requires a very large and expansive laboratory at the experimental level. ATK-VNL helps students to understand the electronic, optical, thermal, mechanical and other properties of various nano-structures and materials at the atomic level.~~ **Simulation Lab-II** 1. ~~To study transport properties of armchair graphene nano-ribbon devices.~~ 2. ~~To study transport properties of zigzag graphene nano-ribbon devices.~~ 3. ~~To analyse chlorine sensing properties of zigzag boron phosphide nano-ribbons through electronic properties.~~ 4. ~~To analyse chlorine sensing properties of zigzag boron phosphide nano-ribbons through transport properties.~~ 5. ~~To calculate binding energy of boron nitride nano-ribbons.~~ 6. ~~To calculate ionization energy and affine energy of boron doped benzene molecule in isolated (gas phase) and in SET environment.~~ 7. ~~To calculate and analyse transmission spectra of a molecule based nano-device.~~ 8. ~~To calculate magnetic moment of a molecular Junction.~~ 9. ~~To study I-V characteristic for a molecular Junction.~~ ~~To investigate spin-dependent I-V curve of single molecule junction.~~	**Write the Computer program to:** **1. Find the roots of a polynomial or transcendental equation using Bisection, Iteration, Newton-Raphson, Ramanujan's, Quotient-difference methods.** **2. Interpolate data using forward, backward and central difference, Newton's general and Lagrange interpolation methods.** **3. Find the least square fit using Straight line and polynomial.** **4. Differentiate and integrate functions using Cubic spline, Trapezoidal, Simpson's, Gaussian integration. To calculate double integral.** **5. Simple Linear Algebra manipulations and calculating inverse and eigenvalue problems using inbuilt libraries.** **6. Solve single and couple ordinary differential equations using Euler's and Runge-Kutta method.** **7. Solving Partial differential equations.** **8. One dimensional single orbital tight-bonding model, with random onsite energies. Calculate the eigenvalues, density of states and site dependent electronic occupation for given electron density.** **9. Compare results for different strength of disorder.** **10. Setup a metropolis algorithm based Monte Carlo simulation of 1d ferromagnetic ising model. Calculate temperature dependence of total energy, specific heat, magnetization and magnetic susceptibility.**	scientific training today. Without writing codes for all the numerical methods studied in the course will be useless. Students will be required to write their own coded and test all the techniques studied in the class.
12.	PHY 513L Nano Fabrication and Characterizatio	After completion of this course, the students will be able to- • understand basic			**No change in entire course**

	n Lab-II	principles of the techniques presented in the course, their advantages and limitations. Furthermore, the student should understand the requirements for samples suitable for each technique. • perform simple and routine operations on the experimental setups.		
13.	BT 518 Nano-Engineering of Biological Systems	After completion of this course, the students will be able to- • explain the concepts of nanotechnology and nanoscience and account for the importance of which in the development of biomedical surface science, • explain the interdisciplinary nature of nanotechnology, using examples from biology, medicine, chemistry and physics, • evaluate the different technologies used in the synthesis and analysis of nanostructures, and	**Recommended Books** 1. Enderle, J., & Bronzino, J. (2012). *Introduction to biomedical engineering*. Academic press. 2. Bronzino, J. D., & Peterson, D. R. (2014). *Biomedical engineering fundamentals*. CRC press. **Supplementary Reading :** 1. Bronzino, J. D., & Peterson, D. R. (2014). *Biomedical engineering fundamentals*. CRC press. 3. Cromwell, L., Weibell, F. J., & Pfeiffer, E. A. (2018).*Biomedical instrumentation and measurements* (Vol. 1). Pearson. **Suggested –web resources** https://ocw.mit.edu/search/ocwsearch.htm?q=ph%20sensorss https://ocw.mit.edu/search/ocwsearch.htm?q=cell%20structure	**No change in entire course** Update e-Resources

		also the phenomena that determine the interactions between nano objects and biological and artificial interfaces		
14.	CHEM 508 Organic and Polymer Technology	After completion of this course, the students will be able to- • isolate the key design features of a product which relate directly to the material(s) used in its construction • describe the role of rubber-toughening in improving the mechanical properties of polymers • identify the repeat units of particular polymers and specify the isomeric structures which can exist for those repeat units • estimate the number- and weight-average molecular masses of polymer samples given the degree of polymerisation and mass fraction of chains present.	**Recommended Books** 1. Nicolais, L., & Carotenuto, G. (Eds.). (2004). *Metal-polymer nanocomposites*. John Wiley & Sons.. 2. Strobl, G. R., & Strobl, G. R. (1997). *The physics of polymers*(Vol. 2). Berlin: Springer.. 3. Fried, J. R. (2014). *Polymer science and technology*. Pearson Education.. **Suggested –web resources** https://nptel.ac.in/courses/113105028/ https://ocw.mit.edu/search/ocwsearch.htm?q=metal%20containing%20polymers	**No change in entire course** Update e-Resources
15.	ELE 504 MEMS and NEMS Technology	After completion of this course, the students will be able to- • understand the	**Recommended Books** 1. Senturia, S. D. (2007). *Microsystem design*. Springer Science & Business Media. 2. Alvi, P. A. (2014). MEMS Pressure Sensors: Fabrication and Process Optimization.	**No change in entire course** Update e-Resources

		operation of micro devices, micro systems and their applications • gain a knowledge of basic approaches for various sensor design • gain a knowledge of basic approaches for various actuator design • gain the technical knowledge required for computer-aided design, fabrication, analysis and characterization of nano-structured materials, micro- and nano-scale devices.	3. Gad-el-Hak, M. (2001). *The MEMS handbook*. CRC press. 4. Sze, S. M. (2008). *Semiconductor devices: physics and technology*. John Wiley & Sons. **Suggested –web resources** https://ocw.mit.edu/search/ocwsearch.htm?q=mems https://nptel.ac.in/courses/105105108/24	
	Reading Elective-I*			
16.	BT 601R Nanotechnology in Healthcare and Environment	After completion of this course, the students will be able to- • describe how the environment and human health interact at different levels. • demonstrate the knowledge and skills needed to improve the environmental sustainability of health systems. • discuss how the duty of a doctor to protect and	**Recommended Books** 1. Rao, C. N. R., Muller, A., & Cheetham, A. K. (2004). The chemistry of nanoparticles: synthesis, properties and applications. 2. Challa, K. (2006). Tissue, cell and organ engineering. 3. Challa, R. K., & Kumar, R. (2007). Nanomaterials for medical diagnosis and therapy. *Mass Spectrometry*, *1*, 2. Supplementary Reading: 1. Goddard III, W. A., Brenner, D., Lyshevski, S. E., & Iafrate, G. J. (Eds.). (2007). *Handbook of nanoscience, engineering, and technology*. CRC press. 2. Bhushan, B. (Ed.). (2017). *Springer handbook of nanotechnology*. Springer.	**No change in entire course** Update e-Resources

		promote health is shaped by the dependence of human health on the local and global environment.	**Suggested –web resources** https://www.futurelearn.com/courses/nanotechnology-health https://elearninguoa.org/course/health-nanotechnology-nanomedicine/nanotechnology-and-nanomedicine https://www.edx.org/learn/nanotechnology	
17.	MGMT 601R Development of Nanotechnology: A Global Aspect	After completion of this course the student will be able to: • understand the role of nanotechnology in various aspects globally • cope up the advancement in new technologies using nanotechnology	**Recommended Books** 1. Maclurcan, D., & Radywyl, N. (Eds.). (2011). *Nanotechnology and global sustainability*. CRC Press 2. Fulekar,M.H. Pathak B., R K Kale (2013) Environment and Sustainable Development, (Springer Press). 3. Parker, R. A., & Appelbaum, R. P. (Eds.). (2013). *Can Emerging Technologies Make a Difference in Development?*. Routledge. **Suggested –web resources** http://www.greeknewsagenda.gr/index.php/topics/business-r-d/6583-university-of-athens-online-courses-on-nanotechnology-and-nanomedicine https://www.coursera.org/learn/nanotechnology	**No change in entire course** Update e-Resources
18.	MGMT 602R Nanotechnology and Society	After completion of this course the student will be able to: • understand the impact of nanotechnology in routine life • understand the impact of nanotechnology on society	**Recommended Books** 1. Fritz, S., & Roukes, M. L. (2002). *Understanding nanotechnology: from the editors of Scientific American*. Warner Books.. 2. Ratner, M. A., & Ratner, D. (2003). *Nanotechnology: A gentle introduction to the next big idea*. Prentice Hall Professional. 3. Jasanoff, S., Markle, G. E., Peterson, J. C., & Pinch, T. (Eds.). (2001). *Handbook of science and technology studies*. Sage publications.. 4. MacKenzie, D., & Wajcman, J. (1999). *The social shaping of technology* (No. 2nd). Open university press. 5. Pickering, A. (Ed.). (1992). *Science as practice and culture*. University of Chicago Press. **Suggested –web resources** https://www.mrs.org/docs/default-source/programs-and-outreach/strange-matter.green-earth/nanotechnology-and-society-a-practical-guide-to-engaging-museum-visitors-in-conversations.pdf?sfvrsn=bf66fa11_0 http://www.cns.ucsb.edu/about/nanotechnology-society.html	**No change in entire course** Update e-Resources

	Reading Elective-II*			
19.	BIO 604R Tissue Engineering	After completion of this course the student will be able to- • understand the basic mechanism of biological systems using nano-science and technology. • understand concept of tissue engineering	**Recommended Books** 1. Palsson, B. O., Bhatia, S. N., & Prentice, P. (2004). Reviewed by Kam W. Leong. *Molecular Therapy*, *9*(4). 2. Vunjak-Novakovic, G., & Freshney, R. I. (Eds.). (2006). *Culture of cells for tissue engineering* (Vol. 7). John Wiley & Sons. **Supplementary Readings:** 1. Joseph D., Bronzino (2006) The Biomedical Engineering –Handbook, (CRC; 3rd edition) **Suggested –web resources** https://nptel.ac.in/courses/102106036/ https://ocw.mit.edu/search/ocwsearch.htm?q=bio%20materials	**No change in entire course** Update e-Resources
20.	CHEM 601R Nano-Catalysis	After completion of this course the student will be able to- • understand the basic mechanism of chemical reaction • understand the role of nano-catalysis.	**Recommended Books** 1. Levenspiel, O. (1999). Chemical reaction engineering.*Industrial & engineering chemistry research*, *38*(11), 4140-4143.. 2. Carberry, J. J. (2001). *Chemical and catalytic reaction engineering*. Courier Corporation. 3. Satterfield, C. N. (1970). *Mass transfer in heterogeneous catalysis*. The MIT Press. **Suggested –web resources** https://ocw.mit.edu/search/ocwsearch.htm?q=%20nano%20catalysis https://nptel.ac.in/courses/103108097/28	**No change in entire course** Update e-Resources
21.	ELE 601R RF and MMIC Design	After completion of this course the student will be able to- • understand radio frequency systems • design the new electronic devices.	**Recommended Books** 1. Robertson, I. D., & Lucyszyn, S. (Eds.). (2001). *RFIC and MMIC Design and Technology* (No. 13). Iet. **Suggested –web resources** https://ocw.mit.edu/search/ocwsearch.htm?q=mesfet https://nptel.ac.in/courses/117107095/20	**No change in entire course** Update e-Resources

Verified

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