INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-701** Course Title: **Numerical Analysis and Computational Techniques**

2. Contact Hours: **L: 2** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 2

4. Relative Weightage**:** **CWS** 20 **PRS** 20 **MTE** 20 **ETE** 40 **PRE** 30

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. **Objective of Course:** To provide the knowledge of computation with suitable mathematical software and its applications to solve the problems of condensed matter physics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to mathematical software/language:** Concept of programming in Matlab/Mathematica, input/output, interactive input, loading and saving data, loops, branches and control flow, matrix and array operations, eigenvalues and eigenvectors.	6
2.	**Sub programs:** Array of dimensional variables, subroutines, sub-programming, functions sub-programming, Advantages of modular programming, built-in functions, scripts, functions, sharing of variables between modules.	5
3.	**Graphics:** 2D plots, style options, axis control, overlay plots, subplot, histogram, 3D plots, mesh and surface plots, contour plots.	4
4.	**Numerical computation:** Computer programs for: solving linear system of simultaneous equations, nonlinear algebraic equation, roots of polynomials, curve fitting, polynomial curve fitting, least square curve fitting, interpolation, data analysis and statistics. Numerical integration, Quadrature, Monte-Carlo simulation, ordinary differential equation, first order and second order ODEs, partial differential equation methods (the finite difference method & the finite element method).	13
	Total	**28**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Pratap, R., "Getting started with MATLAB 7", Oxford University Press.	2006
2.	Gilat, A., "Matlab: An Introduction with Applications", Wiley.	2008
3.	Tao, P., "Computational Physics", Cambridge University Press.	2005
4.	David, P., "Computational Physics", John Wiley & Sons	1973
5.	Wolfram, S., "The Mathematica Book," 5th Ed., Wolfram Media	2003
6.	Gerald, C. F. and Wheatley, P. O., "Applied Numerical Analysis", 7th Ed, Addison Wesley	2003

S. No.	List of Experiments
1.	Eigen-value problem: 1-D square potential well
2.	Stochastic methods for multidimensional integrals
3.	Study of systems with chaotic dynamics
4.	Solving Kronig-Penny Model
5.	Study of doping profile in semiconductors
6.	Variation of dielectric constant for composite materials
7.	Calculation of modes of an optical waveguide
8.	Monte-Carlo simulations (Ising Model of magnetism)
9.	Molecular Dynamics Simulations

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: DEPARTMENT OF PHYSICS

1. Subject Code: PHN-703 Course Title: Fabrication and Characterization Techniques

2. Contact Hours: L: 3 T: 0 P: 0

3. Examination Duration (Hrs.): Theory Practical

4. Relative Weightage: CWS 25 0 MTE 25 ETE 50 PRE 0

5. Credits: 3 6. Semester: Autumn 7. Subject Area: PCC

8. Pre-requisite: Nil

9. Objective: To gain insight of fabrication and characterization of electronic and photonic materials devices

10. *Details of Course:*

S. No.	*Contents*	Contact Hours
1.	**Lithography:** Patterning, various kinds of resists, Spin Coating, Soft bake, Lithography techniques (Photo, E-beam, X-ray), Exposure, Resolution, Contact Aligners, Projection Aligners, Multiple stage lithography, Development, Post-development, Resist removal.	**6**
2.	**Additive Techniques:** Crystallography, Thermodynamics of Material Growth, Kinetics and Nucleation; Grain growth, Physical Vapor Deposition, Evaporation (Thermal, E-beam), Sputtering (DC, RF), Cosine Law of Deposition, Doping of Si, Oxidation of Si, Chemical Vapor Deposition, ion-exchange method, Pulse laser deposition	**12**
3.	**Dry Etching Techniques:** Overview, Dry Etching, Diode Plasmas, Triode Plasmas, DC Plasmas (Diode discussion), Physical Etching, Plasma Etching, Physical / Chemical Etching, RF Plasmas (Diode), Triode Configuration, Deep Reactive Ion Etching (DRIE), Reaction Mechanisms in Dry Etching	**8**
4.	**Wet Etching Techniques:** Wet Isotropic and Anisotropic Etching of Si, Etching with Bias and/or Illumination of the Semiconductor, Etch-stop techniques, Issues in Wet Bulk Etching	**6**
5.	**Characterization:** Structural characterization: X-ray Diffraction, X-ray Reflectivity, RHEED. Microscopy: Optical Microscopy: Scanning Electron Microscopy, Atomic Force Microscopy. Electrical Transport Characterization, Chemical characterization; Optical Characterization: Ellipsometer, Prism Coupling Method, Spectro-photometer.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Milton Ohring , "Materials Science of Thin Films", Second Edition, Elsevier	2001
2.	Ludwig Reimer, "Scanning Electron Microscopy Physics of Image Formation and Microanalysis", Second Edition, Springer	1998
3.	Harry J. Levinson, "Principles of Lithography", Second Edition, SPIE Press	2005
4.	Chris Mack, "Fundamentals of Microfabrication The Science of Miniaturization", Second Edition, CRC Press	2002
5.	Harland G. Tompkins, "Handbook of Ellipsometry", William Andrew Publishing, Springer-Verlag GabH & Co. KG	2005
6	Ayahiko Ichimiya and Philip I. Cohen, "Reflection High-Energy Electron Diffraction", CAMBRIDGE	2004
7	Jens Als-Nielsen, Des McMorrow, "Elements of Modern X-ray Physics" Second Edition, Wiley	2011
8	Sami Franssila, " Introduction to Microfabrication" Second Edition, Wiley	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PH-707** Course Title: Laboratory Work in Solid State Electronic Materials

2. Contact Hours: **L: 0** **T: 0** **P: 6**

3. Examination Duration (Hrs.): **Theory** 0 **Practical** 6

4. Relative Weightage**:** **CWS** 0 **PRS** 50 **MTE** 0 **ETE** 0 **PRE** 50

5. Credits**:** 3 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. Objective: **To impart practical knowledge in Solid Sate Electronic Materials**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Study of variation of resistivity with temperature of metal and highly resistive materials by Four Probe Technique.	14 x 6
2.	Mapping and analysis of the resistivity of large samples (thin films, superconductors) by Four probe Technique.	
3.	To study the temperature dependence of Hall coefficient of n- and p- type semiconductors.	
4.	(a) To measure the dielectric constant and Curie temperature of given ferroelectric samples. (b) To measure the coercive field (E_c), remanent polarization (P_r), Curie temperature (T_c) and spontaneous polarization (P_s) of Barium Titanate ($BaTiO_3$).	
5.	Thermoluminescence in alkali halides crystals. (a) To produce F centers in the crystal exposing to X-ray /UV source. (b) To determine activation energy of the F-centers by initial rise method.	
6.	Verification of Bragg's law and determination of wavelength/energy spectrum of X-rays.	
7.	Study of solar cell characteristics and to determine open circuit voltage 'V_{oc}' , short circuit current 'I_{sc}', Efficiency (η), fill factor, spectral characteristics and chopper characteristics.	
8.	To measure the magnetoresistance of semiconductor and analyze the plots of $\Delta R/R$ and log-log plot of $\Delta R/R$ Vs magnetic field.	
9.	To determine the coercivity, saturation magnetization and retentivity of ferromagnetic samples using magnetic hysteresis loop tracer	
10.	To study the temperature dependence of Laser diode characteristics	
11.	To determine transition temperature of given superconducting material and study Meissner effect.	
12.	To measure critical current density of given superconductor and study its	

	field dependence.	
13	To determine the value of Lande's 'g' factor using ESR spectrometer.	
14	To study C-V characteristics of various solid state devices and materials (like p-n junctions and ferroelectric capacitors).	
	Total	**84**

11. Suggested Books:

S. No.	**Name of Authors/Book/Publisher**	**Year of Publication/Reprint**
1.	Melissinos, A.C. and Napolitano, J., "Experiments in Modern Physics", Academic Press.	2003
2.	Sze, S.M., "Semiconductor Devices Physics and Technology", John Wiley and Sons.	2002
3.	Nakra, B.C. and Chaudhary, K.K., "Instrumentation Measurements and Analysis", Tata McGraw Hill.	2002
4.	Sayer, M. and Mansingh, A., "Measurement, Instrumentation and Experiment Design in Physics and Engineering", Prentice Hall.	2000
5.	Runyan, W.R., "Semiconductor Measurements and Instrumentation", McGraw Hill	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **DEPARTMENT OF PHYSICS**

1. Subject Code: **PHN-709** Course Title: **Semiconductor Device Physics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theo** 3 **Practi** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. Objective: **To familiarize students with the Advanced Electronics Devices**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of P-N Junctions and Bipolar Junction Transistors:** Energy bands, direct and indirect band gap semiconductors, intrinsic and extrinsic material, properties and characteristics of p-n junctions, structure and working principle of Bipolar Junction Transistors.	**7**
2.	**Junction Field Effect Transistor (JFET):** Structures of n- and p-channel JFET, Pinch-off and saturation, Gate Control, Current Voltage characteristics; Metal-Semiconductor FET (MESFET), GaAs MESFET, High Electron Mobility Transistor (HEMT). **Metal Oxide Semiconductor FETS (MOSFETs):** Structure and working principle of enhancement type and depletion type MOSFETs. Ideal MOS diode, inversion layer, threshold voltage, MOS C-V curve, Effects of work function difference and interface charge on threshold voltage, Output and transfer characteristics of enhancement MOSFET, Control of threshold voltage, SOI Devices, FinFET; Junctionless Transistors.	**10**
3.	**Tunnel Devices:** Tunnel diode, Band diagram, the tunneling current, the excess current, and the diffusion current, MIS Tunnel Devices, Fowler-Nordheim Tunneling, Direct Tunneling, MIS Switch Diode, MIM Tunnel Diode, Hot-Electron Transistors, Resonant tunneling diode (RTD), Tunnel FET	**10**
4.	**IMPATT Diodes:** Static characteristics, Breakdown Voltage, Avalanche Region and Drift Region, Dynamic characteristics, Temperature and Space-Charge Effects, Power and Efficiency, Large-Signal Operation, Power-Frequency Limitation, Limitation on	**5**

	Efficiency, Device Design and Performance, BARITT Diode, Current Transport, Small-Signal Behaviors, TUNNETT Diode.	
5.	**Single Electron Devices:** Single Electron transistors; Single Electron Box, Quantum Resistance, Quantum Conductance, Coulomb Blockade, Stability Diagram, Quantum Coulomb Blockade, Single Electron Turnstile; Single Electron Pumps.	**10**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors/Book/Publisher**	**Year of Publication/Reprint**
1.	Sze, S.M. and Kwok, K. Ng, **"**Semiconductor Devices: Physics and Technology**"**, Third Edition, John Wiley and Sons.	2007
2.	Streetman, B.G., Banerjee, S. K. **"**Solid State Electronic Devices", Sixth Edition, PHI Learning Private Limited.	2013
3.	Tyagi, M.S., **"**Semiconductor Materials and Devices**"**, John Wiley and Sons.	2008
4.	Millman J, Halkias C. C., Satyabrata J, "Electronic Devices & Circuits", Tata McGraw Hill	2007
5.	Single Charge Tunneling: Coulomb Blockade Phenomena In Nanostructures by Hermann Grabert, Michel H. Devoret: Springer	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **PHYSICS**

1. Subject Code: **PHN-711** Course Title: **Laboratory Work in Photonics**
2. Contact Hours: **L: 0** **T: 0** **P: 6**
3. Examination Duration (Hrs.): **Theory 3** **Practical 0**
4. Relative Weightage**:** **CWS** 0 **PRS** 50 **MTE** 0 **ETE** 0 **PRE** 50
5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: PCC**
8. Pre-requisite**:** **Nil**
9. Objective: To impart practical knowledge of photonic components and devices.

10. Details of Course:

	Contents	**Contact Hours**
	List of experiments 1. Characterization of single-mode fiber: mode-field diameter, bend loss and cut-off wavelength. 2. Characterization of multi-mode fiber: numerical aperture and refractive index profile. 3. Characterization of planar optical waveguides: refractive index profiling by prism coupling method. 4. Study of acousto-optic modulation. 5. Study of electro-optic modulation. 6. Characterization of light emitting diode. 7. Characterization of Laser Diode. 8. Characterization of photo-voltaic solar cell. 9. Characterization of photodetectors. 10. To study characteristics of an opto-coupler. 11. Deposition of thin films by thermal evaporator and spin coating and optical characterization by spectro-photometer. 12. Study of optical time domain reflectometry.	84

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Shenoy M R, Khijwania S K, Ghatak A K and Pal B P, "Fiber Optics Through Experiments," Viva Books	2009
2.	Ghatak A. and Thyagarajan K., "Optical Electronics," Cambridge University Press	2003
3.	Agrawal G. P., "Optical Fiber Communication System," Wiley Interscience	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **PHYSICS**

1. Subject Code: **PHN-713** Course Title: **Optical Electronics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: PCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the concepts and related phenomena of light matter interaction for applications in optical communication system and photonic devices.

10. Details of Course:

Sl.No	**Contents**	**Contact Hours**
1.	Review of Maxwell's equations, wave propagation in isotropic and anisotropic dielectric media, double refraction, plane waves in anisotropic media, wave and ray refractive indices, index ellipsoid.	6
2.	Fundamentals of lasers, light amplification, threshold condition, laser rate equations, line broadening, longitudinal modes of a laser, transverse modes of a laser, Q switching and mode locking, basics of semiconductor lasers.	8
3.	Electromagnetic analysis of symmetric dielectric planar waveguide, TE and TM modes, power associated with the modes, salient features of optical fibers, weakly guiding optical fiber, LP modes of a step-index optical fiber, single mode optical fiber and its characteristics.	9
4.	Electro-optic effect in KDP, $LiNbO_3$ and $LiTaO_3$, longitudinal and transverse modes, general considerations on modulator design.	5
5.	Acousto-optic effect, Raman-Nath and Bragg diffraction, small and large angle Bragg diffraction, acousto-optic modulator, deflector and spectrum analyzer.	5
6.	Nonlinear optical effects, second harmonic generation, sum and difference frequency generation, optical parametric amplification, self-phase modulation, stimulated Raman scattering, stimulated Brillouin scattering	9
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication/ Reprint
1.	Ghatak A. and Thyagarajan K., "Optical Electronics," Cambridge University Press	2003
2.	Saleh B. E. A., and Teich M. C., "Fundamentals of Photonics," Wiley Eastern	2007
3.	Svelto O., "Principles of Lasers", Springer-Verlag	2010
4.	Agrawal G. P., "Optical Fiber Communication System," Wiley Interscience	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPAT./CENTRE: **Physics Department**

1. Subject code: **PHN-715** Course Title: **Analog Integrated Circuit Design**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hours): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credit: **4** 6. Semester: ******** 7. Subject Area: **PEC**

8. Pre-requisite: **Basics Electronics**

9. Objective: **To familiarize students with the basics of Analog Integrated Circuits**

10. Details of Course:

Sl No.	Content	Contact Hours
1	**Feedback Systems and Stability** Discreet time signals, System State Response, loop gain, delay in loop, Negative Feedback Amplifiers, Phase Margin. Review of Semiconductor Devices.	8
2	**Block Label Design** Operational Amplifiers realization using controlled sources, Single stage opamp realization and its characteristics, Two stage and three stage miller compensated opamp, Feedforward Compensated opamp, typical opamp data sheet, opamp offset, transimpedence amplifiers.	6
3	**Components on IC** Components available in a CMOS process, MOS transistors basics, Parasitics, speed and mismatch, Noise in resistors, Noise in MOS transistors, Noise Scaling	6
4	**Opamp and amplification stages** Basic amplifiers stages, common drain; Frequency response of amplifiers, Common source amplifiers frequency response, common mode rejection ratio and examples, Differential Amplifiers,	6
5	**Opamp design** Differential and common mode half circuits, Differential pair with active load, Fully Differential single stage and two stage opamp Circuits, Fully Differential single stage opamp, common mode feedback, circuit simulator and analysis	8
6	**Phased Locked Loop:** Frequency Multiplier, Phase domain Model, Type I, II PLL transfer function, noise and implementation, Oscillator phase noise, LC and ring Oscillators	4
7	**Miscellaneous Components**	4

	Voltage and current generators, low dropout regulators, continuous time filters, Switched Capacitor filters.	
	Total	**42**

List of Books

S.No.	Name of Authors/ Publishers	Year of Publication/Reprint
1.	*Analog integrated circuit design, T.C. Carusone, Davis Johns, Ken Martin, J wiley & sons, Inc.*	*2012*
2.	*Control Systems: Principles and Design, Tata McGraw-Hill Education*	*2002*
3	*Behzad Razavi, Design of analog CMOS integrated circuits, MacGraw-Hills*	*2000*
4	*Sergio Franco, Design with operational amiplifiers and analog ICs, Tata McGraw-Hill,*	*2002*
5	*Paul R Gray and Robert G. Meyer, Analysis and Design of Analog Integrated Circuits, Wiley;*	*2009*

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF THE DEPAT./CENTRE: **Physics Department**

6. Subject code: **PHN-717** Course Title: **Digital Signal Processing**

7. Contact Hours: **L: 3** **T: 1** **P: 0**

8. Examination Duration (Hours): Theory **3** Practical **0**

9. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

10. Credit: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **None**

9. Objective: **To familiarize students with the basics of Digital Signal Processing**

10. Details of Course:

Sl No.	Content	Contact Hours
1	**Sampling and Reconstruction of continuous time signals**: Periodic sampling, Frequency domain representation of sampling, Reconstruction of a band limited signal from its samples, Changing the sampling rate using discrete time processing, Decimation and Interpolation.	4
2	**Characterization and properties of discrete time signals and systems:** Discrete-Time sequences and systems, Properties of linear time-invariant systems, Linear convolution, Eigen functions for linear time-invariant systems, Linear constant-coefficient difference equations.	6
3	**Computation of DTFT and DFT and its properties** Representation of sequences by discrete time Fourier transforms (DTFT), Symmetry properties of the Fourier transform, Fourier transform theorems. The Fourier transform of periodic signals, Sampling the Fourier transform, The discrete Fourier transform (DFT) and its properties, Circular and linear convolution using the discrete Fourier transform.	8
4	**Fast Fourier Transform (FFT) algorithms, The Z-transform and its properties:** Efficient computation of DFT, Goertzel algorithm, Decimation in-Time FFT algorithm, Decimation-in-Frequency FFT algorithm, Z-Transform, Region of convergence of the ZT, and its properties.	4
5	**Transform analysis of linear time invariant (LTI) systems, Implementation of structures for discrete time systems:** The frequency response of LTI systems, Frequency response for rational system functions, All pass and minimum-phase systems. Block diagram and signal flow graph representation of linear constant-coefficient difference equations, Basic structures for infinite impulse response (IIR) and finite impulse response (FIR) systems, Transposed forms	8
6	**Digital filter design techniques:** Design of Discrete-time IIR Filters from Continuous-time Filters, Design of FIR filters by windowing, Brief overview of optimum and equi-ripple approximation of FIR filters,	4
7	**Overview of Digital Image Processing:** Introduction to digital image processing (DIP), concept of dimension, concept of	8

	bits per pixel, pixel resolution, image transformation, convolution and reconstruction, low and high pass filters, optical character recognition and its applications.	
	Total	**42**

List of Books

S. No.	Name of Authors/Book/Publisher	Year of Publication/Reprint
1.	Sze, S.M. and Kwok, K. Ng, **"**Semiconductor Devices: Physics and Technology**"**, Third Edition, John Wiley and Sons.	2007
2.	Streetman, B.G., Banerjee, S. K. **"**Solid State Electronic Devices", Sixth Edition, PHI Learning Private Limited.	2013
3.	Tyagi, M.S., **"**Semiconductor Materials and Devices**"**, John Wiley and Sons.	2008
4.	Millman J, Halkias C. C., Satyabrata J, "Electronic Devices & Circuits", Tata McGraw Hill	2007
5.	Single Charge Tunneling: Coulomb Blockade Phenomena In Nanostructures by Hermann Grabert, Michel H. Devoret: Springer	1992