VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR

Dean (FW)/
Date: 19/07/13

NOTE

Subject: Department course book - reg.

i. General Information about the departments :

Department of Physics is involved in teaching for UG and PG students of Engineering branches in addition to Sciences. The department has highly qualified and experienced faculty who guide UG, PG and Ph.D. students. The department has number of ongoing as well as completed R&D projects. The areas of research include Nanomaterials, Thin films, Glasses and Glass Ceramics, Ferroelectrics, Magnetic materials, Polymers, Computational Physics, Photovoltaics, sensors, supercapacitors & optoelectronic devices etc. The department has sophisticated instrumentation facilities for synthesis, characterization & applications. M.Sc.(Physics) course lays thrust on fundamental pure physics courses and emphasizes applied Physics courses as well as provides courses on topics of recent interest towards R&D.

ii. List of faculty members

SN	Name	Qualification	E-mail id
1	Prof. V.K. Deshpande	M.Sc. Ph.D.	vkdeshpande@phy.vnit.ac.in
2	Dr. R.S. Gedam	M.Sc. Ph.D.	rsgedam@phy.vnit.ac.in
3	Dr. B.R. Sankapal	M.Sc. Ph.D.	brsankapal@gmail.com
4	Dr. G. Hemchandra	M.Sc.(Tech.), M.Phil. Ph.D.	drghc@rediffmail.com
5	Dr. Mrs. S. R Patrikar	M.Sc. Ph.D.	sujata_patrikar@rediffmail.com
6	Dr. Mrs. A.V. Deshpande	M.Sc. Ph.D.	avdeshpande@phy.vnit.ac.in
7	Dr. Mrs. S.M. Giripunje	M.Sc. PGDCA, Ph.D.	smgiripunje@phy.vnit.ac.in
8	Dr. Mohan Kant	M.Sc. M.Tech. Ph.D.	k.mohankant@gmail.com

iii. Scheme of Examination / Instruction –M Tech Branch:
Credit requirements:

Category	Credits
Departmental core	6
Departmental Electives	
Basic Sciences	
Total	

Details of credits:

I Semester				II Semester			
Code	Course	L-T-P	Credits	Code	Course	L-T-P	Credits
Core				Core			
PHL401	VLSI technology	3-0-0	6				

Elective							
III Semester				IV Semester			
Code	Course	L-T-P	Credits	Code	Course	L-T-P	Credits
Core				Core			
		-				-	
Elective							

Course Number : PHL401 Course Name : VLSI Technology Credits : 6

Syllabus:

Silicon single crystal growth.

Solid state diffusion modeling and technology, ion implantation technology and damage annealing, characterization of impurity profiles.

Oxidation: Kinetics of Silicon dioxide growth both for thick, thin and ultra thin films, oxidation techniques in VLSI and ULSI, characterization of oxides films, low k and high k dielectrics for ULSI.

Environment for VLSI Technology: Clean room and safety requirements, wafer cleaning processes and wet chemical etching techniques.

Lithography: Photolithography, e-beam lithography and newer lithography techniques for VLSI/ULSI, mask generation.

Chemical vapour deposition techniques: CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitrite and metal films, epitaxial growth of silicon.

Metal film deposition: Evaporation and sputtering techniques, failure mechanisms in metal interconnect multilevel metallization schemes.

Plasma and rapid thermal processing, PECVD, plasma etching and RIE techniques, RTP techniques for annealing, growth and deposition of various films for use in ULSI.

Process Integration.

Reference books:

1. S. M. Sze, VLSI technology, II edition, Mc Graw Hill , 1988
2. S. K. Gandhi, VLSI fabrication principles, John Wiley, New York, 1983.
3. C.Y. Chang, S. M. Sze, ULSI technology, Mc Graw Hill companies 1996.

iii. Scheme of Examination / Instruction –M.Sc. Branch:

Credit requirements:

Category	Credits
Departmental core	126
Departmental Electives	10
Basic Sciences/ First Year	78
HM	0-6
OC	0-12

Details of credits:

I Semester				II Semester			
Code	Course	L-T-P	Credits	Code	Course	L-T-P	Credits
Core				Core			
PHL516	Mathematical Physics	3-0-0	6	PHL521	Quantum Mechanics	3-0-0	6
PHL511	Classical Mechanics	3-0-0	6	PHL522	Electrodynamics	3-0-0	6
PHL512	Electronics-1	3-0-0	6	PHL523	Electronics –II	3-0-0	6
PHL513	Computer Programming	3-0-0	6	PHL524	Statistical Mechanics	3-0-0	6
PHL514	Communication skill	2-0-0	Audit	PHL525	Thin Film Techniques	3-0-0	6
PHL515	General Physics Lab	0-0-6	6	PHL526	Electronics Lab	0-0-6	6
PHL513	Computer Programming	0-0-2	2				
Elective							
III Semester				IV Semester			
Code	Course	L-T-P	Credits	Code	Course	L-T-P	Credits
Core				Core			
PHL531	Solid State Physics	3-0-0	6	PHL534	Nuclear and Particle physics	3-0-0	6
PHL532	Atomic and Molecular Physics	3-0-0	6	PHL537	Nanomaterials	3-0-0	6
PHL535	Material Science Lab	0-0-4	4	PHL541	Project Phase - II		6
PHL534	Characterisation Techniques Lab	0-0-4	4				
PHL537	Project Phase - I		6				
Elective							
PHL533	Material Science	3-0-0	6	PHL542	Solar Energy lab	0-0-4	4

Course Number : PHL511 Course Name : Classical Mechanics
Credits : 6

Revision of Newtonian mechanics, constraints, Generalized coordinates Lagrange's equations of motion, Noethers theorem. Hamilton's function and Hamilton's equation of motion, Legendre transform, Phase space, Phase trajectories, Principle of least action, Hamiltonian principle

Two body central force problem, Kepler problem, Scattering, Virial theorem.

Non-inertial frames of reference and pseudo forces, Elements of rigid body dynamics. Small oscillations, Normal mode analysis, Normal modes of a harmonic chain. Principle and postulate of relativity, Lorentz transformation , Length contraction, Time dilation and the Doppler Effect, Relativistic invariance of physical laws.

Recommended Books:

1. Classical Mechanics, H. Goldstein, 2nd Edition, Narosa Pub.

2. Classical Mechanics, N.C.Rana and P.S.Joag ,Tata Mc-Graw Hill Publishing Company

Limited, New Delhi.

3. Mechanics ,L.D Landau and E.M.Lifshitz, Pergamon press, 1960

4. Classical mechanics, K.R.Srinivasa Rao, Univesities Press, Delhi

5. Introduction to mechanics, D. Kleppner, R.J. Kolenkow, McGraw Hill

Course Number : PHL516 Course Name : Mathematical Physics
Credits : 6

Linear vector spaces, Eigen values and Eigen vectors, linear ordinary differential equations of second order, special functions (Hermite, Bessel, Laguerre and Legendre functions).

Fourier series, Fourier Transforms. Elements of complex analysis, analytic functions, Residue theorem.

Green function, Partial differential equation, Laplace equation in two and three dimensions in cylindrical and polar co-ordinates, introduction to wave and heat equation. Introduction toTensors, introductory Group theory: SU (2), O (3)

Recommended Books:

1. Advance Engineering Mathematics , Kreyzig , Wiley India

2. Mathematical Physics, H.K.Dass

3. Mathematical methods for physicists, Arfken, Weber, the Maple vail Manufacturing group, Academic press, 5th edition.

Course Number : PHL525 Course Name :THIN FILM TECHNIQUES : Credits : 6

I) Thin Film Deposition

Brief introduction regarding different methods for thin film formation (Physical and chemical), nucleation and growth mechanism .

Chemical Methods:

II) Chemical bath deposition (CBD) method: Introduction, experimental set-up, basic requirements, basic mechanisms: ion-by-ion, hydroxide cluster and complex decomposition mechanism, deposition from acidic bath, effect of stirring, advantages and disadvantages, a case study of CdS deposition, size quantization in CD films. Brief idea about SILAR

(Successive ionic layer adsorption and reaction) method, advantages over CBD.

III) Electrochemical deposition: Introduction, principle, Faradays laws of electrolysis, experimental set-up, electrode, electrolyte, additives, power supply, substrate, Classification of elctrodeposition: potentiostatic, galvanostatic and cyclic voltametry, Steps involved in electrodeposition process, Over potential term, nucleation and growth mechanism, advantages and disadvantages, a case study.

IV) Spray Pyrolysis: Principle, experimental set-up, preparative parameters: influence of temperature, precursor's solution, Model for films deposition: Atomization of precursor's solution, Aerosol transport, decomposition of precursor, advantages and disadvantages, a case study of SnO2 deposition.

V)Spin Coating: Introduction, experimental set-up, Modeling spin coating, advantages and disadvantages, a case study.

Physical methods: Introduction physical vapor deposition (PVD) and Chemical Vapor deposition (CVD) VI) Evaporation Methods: Thermal Evaporation (vacuum evaporation), Flash evaporation, Laser evaporation, Molecular beam epitaxy

VII) Chemical Vapor Deposition: Basic aspects of CVD, reactions in CVD, Types of CVD: atmospheric pressure, low pressure, plasma enhanced CVD.

VII) Sputtering: Basic principle of sputtering process, brief regarding triode sputtering, ion beam sputtering

Reference books:

1. Thin Film Phenomenon, K. L. Chopra, Mc Graw Hill, 1969.

2. Hand Book of Thin Film Technology, L. I. Maissel and R. Glang Mc Graw Hill, 1969

3. Thin Film Processes. J. L. Vossen and W. Kem, (Academic Press, 1978)

4. The Material Science of Thin Films, M. Ohring (Academic Press, 1972)

5. Chemical Solution Deposition of semiconductor Films, Gary Hodes, Marcel Dekker Inc

6. Thin Film Deposition Using Spray Pyrolysis, J. Electroceramics, 14 (2005) 103-111

7. Preparation of Thin Films, Joy George, Marcel Dekker, Inc.

8. Handbook of semiconductor electrodeposition, R.K.Pandey, S.N.Sahu, S.Chandra

9. Spin Coating for rectangular substrates, A Thesis written by G. A. Luurtesema, University of

California, Berkeley, 1997

Course Number : PHL512 Course Name : Electronics-I : Credits : 6

Operational amplifiers: Differential amplifier using transistors, operational amplifier characteristics, negative feedback configuration, application circuits (inverter, non-inverter, adder, integrator, differentiator, waveform generator, comparator and Schmidt trigger).

Transistor as a switch, feedback in amplifier. Digital logic gates, combinational circuits, Digital techniques and applications, registers, counters and comparators.

A/D and D/A convertors, applications. Transducers (temperature, pressure, magnetic field, vibration, optical and particle detectors), Impedance matching, amplification (op amp based, instrumentation amplifier, feedback) filtering and noise reduction, shielding and grounding.

Recommended Books:

1. Solid state electronic devices, B.G. Streetman, Prentice Hall of India, New Delhi, 1995

2. Microelectronics, J.Millman, Mc Graw Hill International, 1987.

3. Process control and instrumentation, C. D. Johnson, Prentice Hall of India, New Delhi, 2000.

Course Number : PHL521 Course Name : Quantum Mechanics Credits : 6

Basic principles of Quantum mechanics, probabilities and probability amplitudes, wave functions, probability density and probability current. Schrödinger equation, application to linear harmonic oscillator, rigid rotor, hydrogen atom.

WKB approximation, WKB wave function criterion for validity of approximation, application to bound state.
Time dependent perturbation , transition probabilities, Time independent perturbation, degenerate cases, Spin states of electron, Pauli's spin matrix.

Scattering theory, Born approximation, Scattering cross section.

Recommended books:

1. Quantum Mechanics, E.Merzbacher, John Wiley (Asia) 1999

2. Quantum mechanics, G. Aruldhas ,

3. A Textbook of Quantum Mechanics, P.M.Mathews and K.Venkatesan, Tata McGraw Hill 1977

4. Principles of Quantum Mechanics, R.Shankar, Springer (Indian edition)

5 Quantum Mechanics, B.H.Bransden, C.J.Jaochim, Longman Scientific and Technical publication.

Course Number : PHL522 Course Name : Electrodynamics Credits : 6

Gauss law, Laplace and Poisson's equation, induced charges, Green's theorem, Laplace equation, Boundary conditions and uniqueness theorem, method of images, multipole expansion.

Biot-Savart law, magnetic vector potential, magnetic field in matter.

Faraday's law, Maxwell's equations, conservation laws, electromagnetic wave in free space, wave equation, reflection, refraction and propogation of waves. Dipole radiation, electric and magnetic dipole radiation.

Fields at the surface of and within conductor, cylindrical cavity and wave guide, Modes in rectangular waveguide, Modes in dielectric waveguides.

Recommended Books:

1. Classical Electrodynamics, J.D. Jackson, 3rd edition., Wiley, 1999.
2. Introduction to Electrodynamics, D.J. Griffiths, 3rd edition, PHI, 2011
3. Classical Electricity and Magnetism, W.K.H. Panofsky and M. Phillips, 2nd ed.,Addison- Wesley, 1962.
4. Electricity and magnetism, A.S.Mahajan,A.A.Rangwala, Tata McGraw Hill publishing company limited

Course Number : PHL523 Course Name : Electronics-II Credits : 6

IC fabrication

MOSFET characteristics, Homojunction and heterojunction devices, Microprocessor and Microcontroller basics.

Data interpretation and analysis. Precision and accuracy, error analysis, propagation of error,

Least squares fittings, Measurement and control, Signal conditioning and recovery.

Fourier transforms, lock-in detector, box-car integrator, Modulation techniques.

Photodiodes, LEDS, solar cells.High frequency devices

Recommended books:

1. Microprocessor architechture, Programming and Applications with 8085/8086, R.S.Gaonkar , Wiley Eastern

2. Physics of semiconductor Devices,s.M.Sze, Third edition, Wiley

3.Semiconductor Physics and Devices, S.S.Islam, Oxfod University Press

Course Number : PHL524 Course Name : Statistical Mechanics Credits : 6

First law, second law, entropy, Thermodynamic potential, Maxwell relations, chemical potential , Phase equilibria.
Macro & micro state, phase space, density distribution in phase space, micro canonical, canonical and grand canonical ensembles, partition function, free energy, calculation of thermodynamic quantities.

Classical statistical mechanics, Postulates, derivation of thermodynamic laws, equipartition theorem, classical ideal gas, Gibbs paradox, statistics of paramagnetism.

Quantum Statistics, Postulates, density matrix, ensemble, Third Law of Thermodynamics,
ideal gases, Liovillie's theorem. Equilibrium condition, classification of phase transitions, phase diagram, Claussius-Clapeyron equation, Van-der-Walls equation, second order phase transition, Ginzberg – Landau theory, Ising
model, ferromagnetism, law of mass action, diffusion , Brownian motion.

Maxwell – Boltzmann, Bose – Einstein, Fermi – Dirac distributions, Bose condensation, and introduction to non-equilibrium processes.

Recommended Books:

1. Statistical mechanics , Kerson Huang , Wiley India

2. Fundamentals of Statistical mechanics, B.B. Laud, New Age International

3. Statistical Physics, F Reif, Berkley Physics Course, Vol 5

4. Statistical Thermodynamics, M.C.Gupta, New Age International

5. Statistical Mechanics, J.K.Bhattacharya, Narosa publishing house

Course Number : PHL531 Course Name : Solid State Physics Credits : 6

Crystal structure, Bravais lattice, crystal diffraction and reciprocal lattice, group theory, bonding of solids, Phonons, lattice specific heat.

Free electron theory. Drude model of electrical and thermal conductivity.

Electrons in periodic lattice, Bloch theorem, Band theory, Kronig-Penney model,
Classification of solids.

Hall Effect, Effective mass,mobility, Einstein's relation, Generation –Recombination,
continuity equation.

Superconductivity, type-I and type-II superconductors, Josephson junction.
Defects in solids.

Ordered phases of matter: translational and orientational order, types of liquid crystalline order, Quasi crystals.

Recommended Books:

1. Introduction to solid state physics, Charles Kittel, John Wiley and Sons.

2. Solid state physics, A. J. Dekkar, Prentice Hall of India.

3.Solid state physics, C.M.Srivastava

Course Number : PHL532 Course Name : Atomic and Molecular Physics Credits : 6

Vector model of atoms, term for equivalent and non-equivalent electron atoms, Hyperfine structure and width of spectral line, Spectra of alkali metals, Helium Atom Normal and anomalous Zeeman Effect, Paschen –Back effect,

Stark effect, line broadening mechanism, rotation and vibrational spectra of molecules.

Electronic spectra of molecules, Frank-Condon Principle, dissociation energy, rotational fine
structure of electronic vibration transitions, Raman spectra Characterization techniques: NMR spectroscopy, ESR spectroscopy.

Lasers, Theory of optical resonant cavity, Q- switching and mode locking in Lasers, different types of Lasers.

Recommended Books:

1. Atomic Spectra,H.D.White , Tata McGraw Hill Publication.

2. Molecular structure & spectroscopy, G.Aruldhas; Prentice – Hall of India, New Delhi(2001)

3. Fundamentals of molecular spectroscopy, Colin N.Banwell & Elaine M.McCash, TataMcGraw –Hill publishing company limited, Fourth edition(2002).

4. Quantum Physics of atoms, molecules, solids nuclei & particles, Robert Eisberg, Robert Resnick, Second edition, John Wiely & sons(Asia) Ltd.(1985)

5.Physics of atoms and molecules, Bransden, Joachim, Longman publishing group

Course Number : PHL533 Course Name : Materials Science Credits : 6

Introduction to materials. The phase rule, single component system, Binary Phase diagrams Microstructural changes during cooling, Lever Rule, Some typical phase diagrams, Time scale for phase changes, nucleation and growth, nucleation kinetics, growth kinetics and overall kinetics, Applications, Solidification and crystallization, the glass transition.

Fick's laws and their solutions, the Kirkendall effect, mechanisms of diffusion.

Types of polarization, complex dielectric constant, polar and non-polar materials, Dielectric breakdown, piezoelectricity, ferroelectricity, electroceramics, multilayer capacitors.

Magnetic parameters, classification of magnetic materials, Ferromagnetic materials, ferrites,

Applications of magnetic materials, Multiferroics

Recommended Books:

1. Materials Science and engineering: a first course, V. Raghavan fifth Edition(Prentice-Hall of India)2004.

2. Materials Science and Engineering – An Introduction, W.D. Callister Jr. (John Wiley & Sons,)1991.

3. Materials Science, J. C. Anderson, K. D. Leaver, R.D. Rawlings and J.M. Alexander, 4th Edition, Chapman & Hall (1994).

4. Electrical Properties of Materials , seventh Edition l.Solymar and D. Walsh (Oxford Univ.Press Indian Edition) 2006

5. Essentials of Materials Science and Engineering, Askeland, Pradeep Phule, Thomson learning (India Edition)

6. Principles of Materials Science and Engineering, William Smith, McGraw-Hill Publication

Course Number : PHL534 Course Name : Nuclear and particle physics Credits : 6

Basic nuclear properties: size, shape and charge distribution, spin and parity, binding energy, semi empirical formula, liquid drop model.

Nature of nuclear force, form of nucleon-nucleon potential, charge independence and charge symmetry of nuclear forces. Deuteron problem.

Evidence of Shell structure, single particle shell model, its validity and limitations, Rotational spectra, elementary ideas of alpha, beta and gamma decays and their selection rules, fission and fusion.Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

Classification of fundamental forces , Elementary Particles and their Quantum numbers, Gellmann- Nishijima formula, Quark model, baryons and mesons, C, P, T invariance, Application of symmetry arguments to particle reactions, Parity non-conservation in weak interaction, Relativistic kinematics.

Recommended Books :

1. Kenneth S. Krane, Introductory Nuclear Physics, Wiley, New York, 1988

2. Atomic and Nuclear Physics, S.N.Ghoshal , Vol. 2., S.Chand publication

3. Introduction to high Energy Physics, P.H. Perkins, Addison-Wesley, London, 1982.

4. Introduction to Elementary Particles, D. Griffiths, Harper and Row, New York, 1987.

5. Introductory nuclear physics, Y.R. Waghmare, Oxford – IBH, Bombay, 1981.

6. Nuclear Physics, Kapaln, 2nd addition, Narosa, Madras, 1989.

7. Introduction to Nuclear Physics, F.A. Enge, Addison-Wesley, 1975

8. Nucleon interaction, G.E. Brown and A.D. Jackson, North-Holland, Amsterdam, 1976.

Course Number : PHL537 Course Name : Nanomaterials Credits : 6

Basic concept, quantum mechanical view of nanomaterials, surface energy, electrostatic stabilization, Zero-dimensional, one - dimensional and two- dimensional nanomaterials.

Synthesis of nanomaterials by physical methods, chemical methods, biological methods. structural characterization of nanomaterials : XRD, SAXS, SEM, TEM, SPM, gas adsorption, optical spectroscopy Electrical, optical, mechanical and magnetic properties of nanomaterials, applications of nanomaterials

Special nanomaterials: CNT, zeolites, aerogels, oxide polymer structure, porous silicon, Zno nanotube.

Recommended Books:

1. Nanostructures and nanomaterials Synthesis, properties and applications, Guozhong Cao, Imperical college press

2. Fundamentals and applications of nanomaterials, Zhen Guo Li Tan, Artech House (2009)