SACRED HEART COLLEGE (AUTONOMOUS)

Department of Physics

BSc Physics

COURSE PLAN 2014 - 15

(Semester 6)

COURSE PLAN

PROGRAMME	BSC PHYSICS	SEMESTER	6
COURSE TITLE	Computational Physics	CREDIT	3
Theory HOURS/WEEK	3	HOURS/SEM	54
FACULTY NAME	Dr. Roby Cherian & Dr. Siby Mathew		

COURSE OBJECTIVES
Explaining the operation and architecture of 8085 microprocessor and basics of computer hardware
Introduction to C++ Programming and developing simple C++ Programmes
Explaining the Numerical methods involved in Solving various Physics Problems.

SESSION	TOPIC	LEARNING RESOURCES	REMARKS
	MODULE I		
1.	Introduction – Microprocessors	Lecture/PPT	
2.	8085 bus organization-address bus	Lecture/PPT	
3.	data bus	Lecture/PPT	
4.	control bus	Lecture/PPT	
5.	internal data operations	Lecture/PPT	
6.	8085 registers	Lecture/PPT	
7.	accumulator- flags	Lecture/PPT	
8.	program counter-stack pointer, externally initiated operations	Lecture/PPT	
9.	microprocessor architecture	Lecture/PPT	
10.	internal architecture of 8085 microprocessor	Lecture/PPT	
11.	Machine language	Lecture/PPT	
12.	- assembly language- high level language	Lecture/PPT	

13.	Instruction cycle, machine cycle and T state	Lecture/PPT	
14.	instruction format	Lecture/PPT	
15.	addressing modes. The 8085 instruction set- simple programmes for data transfer	Lecture/PPT	
16.	addition and subtraction.	Lecture/PPT	
17.	Programing examples	Lecture/PPT	
18.	Computer hardware	Lecture/PPT	
19.	RAM ROM	Lecture/PPT	
20.	Primary and Secondary memory	Lecture/PPT	
	MODULE II		
21.	Introduction – Why C++?	Lect	
22.	programming basics+ Hands on session	PPT and hands on session	
23.	Programing examples	Activity	
24.	programming basics+ Hands on session	PPT and hands on session	
25.	programming basics+ Hands on session	PPT and hands on session	
26.	Programing examples	Activity	
27.	programming basics+ Hands on session	PPT and hands on session	
28.	Programing examples	Activity	
29.	basic ideas of structures	PPT and hands on session	
30.	Programing examples	Activity	
31.	loops	PPT and hands on session	
32.	Programing examples	Activity	
33.	decisions	PPT and hands on session	
34.	arrays	PPT and hands on session	
35.	arrays	PPT and hands on session	
36.	functions	PPT and hands on session	

37.	functions	PPT and hands on session	
38.	objects	PPT and hands on session	
39.	classes	PPT and hands on session	
40.	CIA-I	Internal Exam	
41.	Programming examples	Activity	
42.	Programming examples	Activity	
	MODULE III		
43.	How to solve physics numerical computationally	Lecture	
44.	Difference between algebraic and transcendental equations	Lecture	
45.	Graphical solving , bisection	Lecture	
46.	false position	Lecture	
47.	Examples	Lecture	
48.	Newton-Raphson methods	Lecture	
49.	Examples	Lecture	
50.	CIA-II	Lecture	
51.	algorithms - numerical integration trapezoidal rule	Lecture	
52.	Simpson's 1/3 rule - algorithm	Lecture	
53.	differential equation- Euler's method	Lecture	
54.	second order Runge-Kutta method algorithm	Lecture	

INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)
1	Before 1st Internal	Writing few simple C++ programming (Best of 3)
2	Before 2nd Internal	Numerical Methods using C++ (Best of 2)

Text Book for C++ Programming:
Object Oriented Programming in Turbo C++ - Robert Lafore (Galgotia pub.)

References
1. Microprocessor architecture, programming and applications- Ramesh S. Gaonkar (Penram Int. Pub.)
2. Fundamentals of Microprocessors and microcomputers- B. Ram (Dhanpat Rai Pub.)
3. Microcomputers and Microprocessors- John Uffenbeck (PHI Pub.)
4. Object oriented programming in Turbo C ++ - Robert Lafore (Galgotia Pub.)
5. Programming with C ++ - John R. Hubbard (Mc Graw Hill Pub.)
6. Numerical method- V. Rajaram (PHI Pub.)
7. Introductory methods of Numerical methods -S.S .Sastry (PHI Pub.)
8. Numerical method with computer programming in C ++ - Ghosh (PHI Pub.)

COURSE PLAN

PROGRAMME	BSC PHYSICS	SEMESTER	6
COURSE TITLE	Nuclear and Particle Physics	CREDIT	3
Theory HOURS/WEEK	3	HOURS/SEM	54
FACULTY NAME	Dr. Jimmy Sebastian		

COURSE OBJECTIVES
Explain the basic principles of Nuclear physics.
Apply the principles of quantum mechanics and classical physics to Nuclear and particle physics
Solve specific problems in Nuclear and particle physics
Criticize the environmental impact of the production of Nuclear energy.

Sessions	**Topic**	**Learning Resources**	**Remarks**
1	Introduction to nuclear physics	Lecture + Interaction	
2	Classification of nuclei – Isotopes, Isobars, Isomers, Mirror nuclei.	Lecture + Interaction	
3	General properties of nucleus – size, nuclear mass, density.	Lecture + Interaction	
4	Charge, angular momentum, nuclear magnetic dipole moments.	Lecture + Interaction	
5	Electric quadrupole moment, Mass defect.	Lecture + Interaction	
6	B.E, B.E. curve.	Lecture + Interaction	
7	Packing fraction, nuclear stability.	Lecture + Interaction	
8	Theories of nuclear composition	Lecture + Interaction	
9	Proton-electron hypothesis – proton - neutron hypothesis.	Lecture + Interaction	

10	Properties of Nuclear forces	Lecture + Interaction	
11	Meson theory of nuclear forces.	Lecture + Interaction	
12	Nuclear shell model.	Lecture + Interaction	
13	Determination of nuclear mass by Bainbridge's mass spectrograph.	Lecture + Interaction	
14	Detectors of nuclear radiations – Ionization chamber.	Lecture + Interaction	
15	G.M Counter.	Lecture + Interaction	
16	Problem Solving	Lecture + Interaction	
17	Natural radioactivity – Radioactive disintegration law	Lecture + Interaction	
18	Half life – Mean life	Lecture + Interaction	
19	Radioactive series.	Lecture + Interaction	
20	Radioactive dating – Uranium dating & Carbon dating	Lecture + Interaction	
21	Range of α particles – range – energy relationship	Lecture + Interaction	
22	Geiger – Nuttal law	Lecture + Interaction	
23	Alpha particle disintegration energy	Lecture + Interaction	
24	Theory of α - delay	Lecture + Interaction	
25	Gamow's theory β- decay	Lecture + Interaction	
26	β ray energy spectrum	Lecture + Interaction	
27	Neutrino hypothesis Positron emission.	Lecture + Interaction	
28	orbital electron capture (Basic ideas only)	Lecture + Interaction	
29	γ decay	Lecture + Interaction	
30	Internal conversion	Lecture + Interaction	

31	Electron positron pair production by γ rays.	Lecture + Interaction	
32	Electron positron annihilation.	Lecture + Interaction	
33	Artificial radioactivity & Transuranic elements. (Basic ideas only)	Lecture + Interaction	
34	Discovery of nuclear fission.	Lecture + Interaction	
35	Fission products. Neutron emission in fission. Energy release in fission.	Lecture + Interaction	
36	Nuclear fission on the basis of liquid drop model chain reaction	Lecture + Interaction	
37	Nuclear reactor	Lecture + Interaction	
38	Breeder reactor Nuclear fusion Energy production in stars.	Lecture + Interaction	
39	Proton-Proton cycle and Carbon Nitrogen cycle.	Lecture + Interaction	
40	Peaceful utilization of fusion power	Lecture + Interaction	
41	Controlled thermo nuclear reactions	Lecture + Interaction	
42	Toroidal confinement - Tokamak	Lecture + Interaction	
43	Nuclear waste disposal. radiation hazards from nuclear explosion – radiation dosage	Lecture + Interaction	
44	Problem Solving Session.	Lecture + Interaction	
45	Particles and antiparticles	Lecture + Interaction	
46	Fundamental interactions in nature.	Interaction	
47	Classification of elementary particles according to nuclear interactions.	Lecture + Interaction	
48	Resonance particles Elementary particle quantum numbers and conservation laws.	Lecture + Interaction	
49	The quark model	Lecture + Interaction	

50	Compositions of hadron according to quark model.	Lecture + Interaction	
51	Cosmic rays - Primary and secondary	Lecture + Interaction	
52	Cosmic rays - Primary and secondary	Lecture + Interaction	
53	latitude effect- altitude effect- east west effect	Lecture + Interaction	
54	Problem solving	Interaction	
55	CIA -1	Interaction	
56	CIA -2	Exam	
57	Discussing problems, the question paper of CIA-II and	Exam	

INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)
1	Before 1st Internal	Individual- Graded – Best of 2 sets
2	Before 2nd Internal	Individual- Graded –Best of 2 sets

ASSIGNMENTS– Details & Guidelines – Will be notified prior to the announcement of the assignment – marks will be scaled to 5.

SEMINARS will be given to each student (20 mins duration) – 5 marks (,)

REFERENCE

1. Nuclear Physics Principles and Applications. Lilley, Pub. John. Wiley

2. Nuclear and Particle Physics S L Kakani and Subhra Kakani -Viva Books 2008

COURSE PLAN

PROGRAMME	BSC PHYSICS	SEMESTER	5
COURSE TITLE	Condensed Matter Physics	CREDIT	3
Theory HOURS/WEEK	3	HOURS/SEM	54
FACULTY NAME	Dr. Sumod SG & Dr. Siby Mathew		

COURSE OBJECTIVES
Explain the basic concepts in Crystalline Physics
Analyze the theories related to free electrons in metals
Explaining the basics of Super conductivity and nanomaterials

SESSION	TOPIC	LEARNING RESOURCES	REMARKS
	MODULE I		
1.	Crystal Structure -	Lecture/PPT	
2.	Crystalline Matter - Bravias Lattice -	Lecture/PPT	
3.	Crystal Systems – Crystal Planes -	Lecture/PPT	
4.	Miller Indices -	Lecture/PPT	
5.	Lattice Constants - Reciprocal Lattice -	Lecture/PPT	
6.	Crystal Structures - sc, bcc, fcc and hcp -	Lecture/PPT	
7.	Bragg's Law -Derivaion	Lecture/PPT	
	Experimental Methods of X-Ray		

8.	diffraction -	Lect	
9.	Problems-discussion	Activity	
10.	Powder method. Bonding in Solids	PPT and hands on session	
11.	Ionic, Covalent, Van der Waal and Metallic Bonding (qualitative) -	PPT and hands on session	
12.	**1st Internal**	Activity	
13.	Binding Energy in Crystals - Madelung Constant	PPT and hands on session	
	MODULE II		
14.	Classification of Magnetic Materials-	PPT and hands on session	
15.	Langevin's theory - Paramagmetism - Curie-	PPT and hands on session	
16.	Weiss Law- Curie temperature -	PPT and hands on session	
17.	Langevin's theory- Diamagnetism	PPT and hands on session	
18.	Antiferromagnetism and Ferrimagnetism –	PPT and hands on session	
19.	Magnetisation - Magnetic Domain	PPT and hands on session	
20.	Structure – Spintronics - Spin Waves.	PPT and hands on session	
21.	Free Electron theory in one dimension-	PPT and hands on session	
22.	Formation of Energy Bands- Bloch Theorem (Statement) - Kronig Penney Model –	Activity	
23.	Brillouin Zones (qualitative) –	Lecture	

24.	Effective Mass- Carriers in Solids-	Lecture	
25.	Metals, Insulators and Semiconductors-	Lecture	
26.	Band Structure-Intrinsic and Extrinsic Semiconductors-	Lecture	
27.	Electric Conductivity-Temperature Dependence-	Lecture	
28.	Hall effect.	Lecture	
29.	Review of Basic Equations -	Lecture	
30.	Dielectric Constant -	Lecture	
31.	Dipole Moment-Polarizability-	Lecture	
32.	Clausius-Mosotti Relation-	Lecture	
33.	Ferrroelectricity	Lecture	
34.	Origin of Magnetism in substances	Lecture	
35.	Problem solving and revision	Lecture	
	MODULE III		
36.	Superconductivity (10 hrs) History of superconductivity-Super conducting phenomena-	Lecture	
37.	Meissner effect-	Lecture	
38.	Penetration depth, critical field and critical temperature-	Lecture	
39.	Type I& II Superconductors-Josephson Effect –	Lecture	
40.	SQUID, Theorems of Super conductivity	Lecture	

41.	- London equation-BCS theory-	Lecture	
42.	Cooper pairs-Explanation	Lecture	
43.	High Tc superconductors and applications.	Lecture	
44.	Materials Science and Technology	Lecture	
45.	Amorphous Semiconductors	Lecture	
46.	- Liquid Crystals –	Lecture	
47.	Polymers - Thin films - Properties-	Lecture	
48.	Crystalline Materials	Lecture	
49.	Applications Crystalline materials	Lecture	
50.	nanostructures	Lecture	
51.	Nanometerials-	Lecture	
52.	Applications of nanomaterials	Lecture	
53.	Revision	Lecture	
54.	Problem session	Lecture	

INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)
1	Before 1st Internal	Problems using Bragg's law and basic crystallography
2	Before 2nd Internal	Dielectrics and magnetism-problems

Basic Reference:

1. Kittel, C. Introduction to Solid State Physics, 8th edition (Wiley)
2. Ashcroft, N.W. & Mermin, N.D. Solid State Physics, TMH
3. Blakemore, J.S. Solid State Physics, 2nd edition (Cambridge)
4 C.L. Arora, Solid State Physics. S Chand.
1. S.O.Pillai, Solid State Physics. New Age International Pub.
2. Superconductivity, Superfluids and Condensate James F Annett Oxford

COURSE PLAN

PROGRAMME	BSC PHYSICS	SEMESTER	6
COURSE TITLE	RELATIVITY AND SPECTROSCOPY	CREDIT	4
Theory HOURS/WEEK	3	HOURS/SEM	54
FACULTY NAME	Prof. Alex Shinu Scaria & Navya S L		

COURSE OBJECTIVES
Explain the general and special theory of relativity
Explain atomic spectra and apply it to the study of magneto-optic phenomenon
Explain the basic concepts of molecular energy levels and hence evaluate molecular spectrum

SESSION	**TOPIC**	**LEARNING RESOURCES**	**REMARKS**
	MODULE I		
1-2	Inertial and non- inertial frames of reference – Galilean transformation	Lect+discussion	
3-4	Significance of Michelson – Morley experiment	Lect+discussion	
5-6	postulates of STR- Lorentz transformation	Lect+discussion	
7	– spatial contraction - time dilation	Lect+discussion	
8	problems	Lect+discussion	
9-10	composition of velocities – Mass of a moving particle	Lect+discussion	
11	problems	Lect+discussion	

12	Equivalence of mass and energy	Lect+discussion	
13	problems	Lect+discussion	
14, 15,16 ,17	Introductory concepts of general theory of relativity	Lect+discussion	
18	problems	discussion	
	MODULE II		
19	Historical introduction	Lect	
20	Electromagnetic spectrum.	Lect+discussion	
21-22	Types of spectra. Absorption and emission of light by atoms	Lect+discussion	
23-24	quantum theory- early atom models	Lect+discussion	
25-27	Bohr model- –electron spin and magnetic moment – Exclusion principle	Lect+discussion	
28-29	Stern – Gerlach Experiment	Lect+discussion	
30-32	Vector atom model – quantum numbers associated with vector atom models	Lect+discussion	
33-35	Total angular momentum and LS coupling– fine structure of Sodium D-lines	Lect+discussion	
36-38	Zeeman effect- quantum mechanical explanation for anomalous Zeeman effect	Lect+discussion	
39	Paschen– Back effect	Lect+discussion	
	MODULE III		
40	Molecular energy levels	Lect+discussion	

41	Electronic, rotational and vibrational energies	Lect+discussion	
42	rotational spectra	Lect+discussion	
43	explanation in terms of rigid rotator model	Lect+discussion	
44	vibrational energy level	Lect+discussion	
45	explanation in terms of harmonic oscillator	Lect+discussion	
46	Electronic energy levels of atoms	Lect+discussion	
47	Fluorescence and phosphorescence	Lect+discussion	
48	Raman effect – experimental arrangement and result	Lect+discussion	
49	Classical theory and its failure	Lect+discussion	
50	quantum theory of Raman effect	Lect+discussion	
51	NMR Spectroscopy	Lect+discussion	
52	Basic principles and instrumentation	Lect+discussion	
53	Medical applications of NMR	Lect+discussion	
54	problems & general conclution	Activity	

INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)
1	Before 1st Internal	Problems (Best of 3)
2	Before 2nd Internal	Problems (Best of 2)

Text Books:

1. Molecular structure and spectroscopy, Aruldas 2nd ed. EEE.
2. Modern Physics, Kenneth S Krane (2nd Edition) -Wiley.
3. Concepts of modern Physics, Arthur Beiser (6th Edition)

References:

1. Spectroscopy: Straughan and Walker –(Vol.1) John Wiley
2. Fundamentals of Molecular Spectroscopy: CN Banwell –(4th edition) TMH .
3. Introduction to Atomic Spectra, HE White, TMH
4. Elements of spectroscopy, Guptha, Kumar and Sharma (Pragathi Prakash)
5. Special Relativity- Resnick, (Wiley)
6. Mechanics – D.S.Mathur (S.Chand).
7. Mechanics by J.C. Upadhayaya (Ramprasad)
8. Semiconductor physics and optoelectronics- V Rajendran, J Hemaletha and M S Gibson

COURSE PLAN

PROGRAMME	BACHELOR OF SCIENCE (PHYSICS)	SEMESTER	6
COURSE TITLE	OPTOELECTRONICS	CREDIT	3
HOURS/WEEK	5	HOURS/SEM	90
FACULTY NAME	V M GEORGE, ROBY CHERIAN		

Course Objectives
Understand the basic concepts of photonics and prcesses in semiconductors.
Understand working and operation of semiconductor optoelectronic devices.
Understand the basic ideas of optical communication.

Session	**Topic**	**Method**	**Remarks**
1	Photodetectors: Introduction	Lecture cum discussion	
2	Classification of detectors	Lecture cum discussion	
3	Classification of detectors	Lecture cum discussion	
4	Qualitative idea of each type- Photo detector parameters	Lecture cum discussion	
5	Qualitative idea of each type- Photo detector parameters	Lecture cum discussion	
6	Noise mechanisms	Lecture cum discussion	
7	Principle and operation of Photodiode	Lecture cum discussion	
8	APD	Lecture cum discussion	
9	Phototransistor	Lecture cum discussion	
10	PIN photodiode –opto-isolators	Lecture cum discussion	
11	Revision/Exercise	Student discussion	

12	Problem solving/Presentation	Student Activity	
13	Solar Cells: Principle	Lecture cum discussion	
14	V-I characteristics	Lecture cum discussion	
15	Fill factor	Lecture cum discussion	
16	Maximum power and conversion efficiency	Lecture cum discussion	
17	Hetero junction solar cells (Qualitative study)	Lecture cum discussion	
18	Exercise/Problem solving	Student Activity	
19	Optical communication:Introduction to Optical communication- Historical perspective	Lecture cum discussion	
20	Advantages and disadvantages of optical communication links in comparison with radio and microwave system and with guided systems	Lecture cum discussion	
21	measurement of information and the capacity of telecommunication channel- Communication system architecture	Lecture cum discussion	
22	basic optical communication system – Definition of attenuation, pulse duration and band width	Lecture cum discussion	
23	Exercise/Problem solving	Student Activity	
24	Optical Modulation: Direct modulation of LED and diode laser.	Lecture cum discussion	

25	Digital and analog modulation of LED and diode laser.	Lecture cum discussion	
26	External modulation.	Lecture cum discussion	
27	Birefringence	Lecture cum discussion	
28	Pockeleffect continue…	Lecture cum discussion	
29	Pockel Effect	Lecture cum discussion	
30	Phase modulation.	Lecture cum discussion	
31	Wave guide modulators .	Lecture cum discussion	
32	Electro-optic Modulators	Lecture cum discussion	
33	Magneto- optic modulators	Lecture cum discussion	
34	Acousto- optic modulators.	Lecture cum discussion	
35	Bipolar controller modulator.	Lecture cum discussion	
	Phase modulation.	Lecture cum discussion	
36	Wave guide modulators .	Lecture cum discussion	
37	Exercise/Assignment discussion	Student Activity	
38	Problem solving.	Student Activity	
39	Fibre optic communication: Introduction to Optical fibres and fibre optic communication	Lecture cum discussion	
40	Types of optical fibres	Lecture cum discussion	
41	Numerical aperture	Lecture cum discussion	
42	Fibre bundles, cables- strength	Lecture cum discussion	
43	fibre optical properties	Lecture cum discussion	
44	Fibre materials	Lecture cum discussion	

45	Classification of fibres – Step index and graded index	Lecture cum discussion	
46	mono mode and multi modefibres	Lecture cum discussion	
47	plastic fibreslatest developed fibres	Lecture cum discussion	
48	Fibre loses.	Lecture cum discussion	
49	Exercise/ Revision/ Assignment	Student Activity	
50	Problem Solving/Presentation	Student Activity	
51	Introduction, Optical radiation and light	Lecture cum discussion	
52	Luminescence and Radiation	Lecture cum discussion	
53	Photometric and Radiometric terms and units	Lecture cum discussion	
54	Inverse square law – verification by photometer	Lecture cum discussion	
55	Demo of Inverse square law	Lecture cum discussion	
56	comparison of efficiency of lightsources available in the market	Lecture cum discussion	
57	recommended values of illumination for various activities (General awareness)	Lecture cum discussion	
58	Revision/Problems	Student activity	
59	Introduction to Photonics – electrons Vs photons – Electronics Vs Optics, Photonics - Photonics and light technology and applications	Lecture cum discussion	
60	Properties of Photons,Gaussian beams – beam characteristics and parameters(Qualitative ideas only)	Lecture cum discussion	
61	Demo of Gaussian beam	Lecture cum discussion	
62	Semiconductors – Intro	Lecture cum discussion	

63	Direct and indirect bandgap semiconductors	Lecture cum discussion	
64	Electron hole pair formation and recombination	Lecture cum discussion	
65	Demonstration of e-h pair formation/recombination	Lecture cum discussion	
66	Radiative and nonradiative recombination and recombination rates	Lecture cum discussion	
67	Absorption in semiconductors – indirect transitions	Lecture cum discussion	
68	exciton absorption	Lecture cum discussion	
69	donor- acceptor band impurity band absorption	Lecture cum discussion	
70	Long wavelength absorption	Lecture cum discussion	
71	Franz Keldysh effect	Lecture cum discussion	
72	Stark effect	Lecture cum discussion	
73	Radiation in semiconductors	Lecture cum discussion	
74	Stokesshift in optical transitions	Lecture cum discussion	
75	Revision/Problems	Student activity	
76	Demonstration of Stoke's shift	Lecture cum discussion	
77	Frank – Condon shift	Lecture cum discussion	
78	Auger recombination	Lecture cum discussion	
79	LED –Principle	Lecture cum discussion	
80	characteristics (V-I & light – current)	Lecture cum discussion	
81	Demo of characteristics	Lecture cum discussion	
82	Materials, efficiencies	Lecture cum discussion	
83	LED structures- hetero junction	Lecture cum discussion	
84	edge emitting LED	Lecture cum discussion	
85	Applications	Lecture cum discussion	

86	Advantages	Lecture cum discussion	
87	Semiconductor lasers – Homo junction	Lecture cum discussion	
88	Hetero junction lasers	Lecture cum discussion	
89	Quantum well lasers wave guiding and index guiding Optical and carrier confinement	Lecture cum discussion	
90	Revision/Problems	Student activity	

References

1. Photonics, Ralf Menzel, Springer
2. Optoelectronics Wilson and Hawkes
3. Semiconductor optoelectronic devices –Pallab Bhattacharya