SYLLABUS for M. Sc. Physics

Choice Based Credit System (Semester Pattern)

Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur

Effective from 2015-2016

Scheme of teaching and examination under semester pattern Choice Based Credit System (CBCS) for M.Sc. Program in Physics

M. Sc. (Physics) Semester I												
Code	Th./Pr.	Teaching Scheme (hrs/week)			CREDITS	Examination Scheme						
		Th.	Pr.	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 1	Paper 1 **Mathematical Physics**	4	-	4	4	3	80	20	100	40	
Core 2	Paper 2 **Complex Analysis and Numerical Methods**	4	-	4	4	3	80	20	100	40	
Core 3	Paper 3 **Electronics**	4	-	4	4	3	80	20	100	40	
Core 4	Paper 4 **Electrodynamics I**	4	-	4	4	3	80	20	100	40	
Pract. Core 1 &2	Practical 1 **(Paper 1 & 2)**	-	8	8	4	3-8*	100**	-	100	-	40
Pract. Core 3 &4	Practical 2 **(Paper 3 & 4)**	-	8	8	4	3-8*	100**	-	100	-	40
Seminar 1	Seminar 1	2	-	2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

M. Sc. (Physics) Semester II											
Code	Th./Pr.	Teaching Scheme (hrs./week)			CREDITS	Examination Scheme					
		Th.	Pr.	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 5	Paper 5 **Quantum Mechanics I**	4	-	4	4	3	80	20	100	40	
Core 6	Paper 6 **Statistical Physics**	4	-	4	4	3	80	20	100	40	
Core 7	Paper 7 **Classical Mechanics**	4	-	4	4	3	80	20	100	40	
Core 8	Paper 8 **Electrodynamics II**	4	-	4	4	3	80	20	100	40	
Pract. Core 5 &6	Practical 3 **(Paper 5 &6)**	-	8	8	4	3-8*	100**	-	100		40
Pract. Core 7 &8	Practical 4 **(Paper 7 & 8)**	-	8	8	4	3-8*	100**	-	100		40
Seminar 2	Seminar 2	2		2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

M. Sc. (Physics) Semester III											
Code	Th./Pr.	Teaching Scheme (hrs./week)			CREDITS	Examination Scheme					
		Th.	Pr.	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 9	Paper 9 **Quantum Mechanics II**	4	-	4	4	3	80	20	100	40	
Core 10	Paper 10 **Solid State Physics and Spectroscopy**	4	-	4	4	3	80	20	100	40	
Core ele. 1	Paper 11 **Any one from subjects below** **E1.1: Materials Science I** **E1.2 X-ray I** **E1.3 : Nanoscience and Nanotechnology I** **E1.4 : Atomic and Molecular Physics I** **E1.5: Applied Electronics I** **E1.6: Methods of Theoretical Physics I** **E1.7 Nonlinear Dynamics I**	4	-	4	4	3	80	20	100	40	
Foundation Course 1	Paper 12 **F1.1 Fundamentals of Spectroscopy** **OR** **F1.2 Fundamentals**	4	-	4	4	3	80	20	100	40	

	of Nanoscience and Nanotechnology										
Pract.Core 9 &10	Practical 5 **(Paper 9 & 10)**	-	8	8	4	3-8*	100**		100		40
Pract. Core ele. 1	Practical 6 **(Paper 11)**	-	8	8	4	3-8*	100**		100		40
Seminar 3	Seminar 3	2		2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

M. Sc. (Physics) Semester IV											
Code	Th./Pr.	Teaching Scheme (hrs./week)			CREDITS	Examination Scheme					
		Th.	Pr,	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 11	Paper 13 **Nuclear and Particle Physics**	4	-	4	4	3	80	20	100	40	
Core 12	Paper 14 **Solid State Physics**	4	-	4	4	3	80	20	100	40	
Core ele. 2	Paper 15 **Part II of subject chosen in Sem. III** **E2.1: Materials Science II** **E2.2 X-ray II** **E2.3 : Nanoscience and Nanotechnology II** **E2.4 : Atomic and Molecular Physics II** **E2.5: Applied Electronics II** **E2.6: Methods of Theoretical Physics II** **E2.7 Nonlinear Dynamics II**	4	-	4	4	3	80	20	100	40	
Foundation Course 2	Paper 16 **F2.1: Spectroscopic Applications** **OR** **F2.2: Optics and Optical**	4	-	4	4	3	80	20	100	40	

	Instruments										
Pract.Core 11 &12 & ele. 2	Practical 7	-	8	8	4	3-8*	100**		100		40
Project	Project	-	8	8	4		100**		100		40
Seminar 4	Seminar 4	2		2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

Note: Th: =Theory; Pr:=Practical/lab, ele.=elective • = If required, for two days. **= The Practical and Project shall be evaluated by both External and Internal Examiner in the respective Department / Center / Affiliated College as per guidelines appended with this direction.

Table of Contents

Revised Syllabus to be implemented from 2015-16
Choice Based Credit System(CBCS)

Subject Scheme of Revised Syllabus 2015-2016 Semester Pattern
Syllabus for Each theory paper is based on 60 clock hours of teaching.

M.Sc. Physics Semester I
1. (Core 1)Paper 1: Mathematical Physics
2. (Core 2) Paper 2: Complex Analysis and Numerical Methods
3. (Core 3) Paper 3: Electronics
4. (Core 4)Paper 4: Electrodynamics I

M.Sc. Physics Semester II
1. (Core 5) Paper 5: Quantum Mechanics-I
2. (Core 6) Paper 6: Statistical Physics
3. (Core 7) Paper 7: Classical Mechanics
4. (Core 8) Paper 8: Electrodynamics II

M.Sc. Physics Semester III
1. (Core 9) Paper 9: Quantum Mechanics-II
2. (Core 10) Paper 10: Solid State Physics and Spectroscopy
3. Any one of the Elective papers from the following list. Paper 11 (Core Elective 1)
E1.1 Materials Science I
E1.2. X-ray I
E1.3Nanoscience and Nanotechnology I
E1.4. Atomic and Molecular Physics I
E1.5Applied Electronics I
E1.6. Methods of Theoretical Physics I
E1.7 Nonlinear Dynamics I

4. Foundation course 1
Any one of following courses: Paper 12 (Not for Physics Students)

F1.1 Fundamentals of Spectroscopy
F1.2 Fundamentals of Nanoscience and Nanotechnology

M.Sc. Physics Semester IV
1. (Core 11) Paper 13: Nuclear and Particle Physics
2. (Core 12) Paper 14: Solid State Physics
3. One of the elective papers from list below Paper 15 (Core Elective 2)
E2.1 Materials Science II
E2.2 X-ray II
E2.3 Nanoscience and Nanotechnology II
E2.4 Atomic and Molecular Physics II
E2.5 Applied Electronics II
E2.6 Methods of Theoretical Physics II
E2.7 Nonlinear Dynamics II

4. Foundation course 2
Any one of the following courses: Paper 16 (Not for Physics students)

F2.1Spectroscopic Applications
F2.2Optics and Optical Instruments.

Scheme of teaching and examination under CBCS.

Sem.	core	Pract. core	Core ele.	Pra. Core Ele.	Fou. course	Project./ Review writing	seminar	Total
I	16	8					2	
II	16	8					2	
III	8	4	4	4	4		2	104
IV	8	4	4		4	4	2	
Total	48	24	8	4	8	4	8	104

Explanatory terms:

1. Core: Main theory papers in the concerned subject.
2. Core Elective: These papers will be specialization in the concerned subject
3. Foundation Course: Student can choose this paper from any subject other than his main subject for post graduation
4. Project **/** Review writing: Project **/** Review writing is in semester IV
5. Seminar: The seminar in each semester shall be presented by the candidate in his **/**her parent department only.

Credits:

It is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work **/** field work per week. If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on the marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Letter Grade	O	A+	A	B+	B	C	P	F	Ab
Grade Point	10	09	08	07	06	05	04	0	0

A student obtaining Grade F shall be considered failed and will be required to reappear for the examination.

Valuation pattern:

Every credit is for 25 marks and valuation and grade points will be given as per following pattern

Marks obtained in Th./pr. Of 100 Marks	Marks obtained in Th./pr. Of 50 Marks	Letter Grade	Grade Point
91-100	46-50	**O**	10
81-90	41-45	A+	09
71-80	36-40	A	08
61-70	31-35	B+	07
51-60	26-30	B	06
41-50	21-25	C	05
=40	=20	P	04
<40	<20	F	0
Ab	Ab	Ab	0

<u>Computation of SGPA and CGP A</u>

Following is the procedure to compute the Semester Grade Point Average (SGPA) and

Cumulative Grade Point Average (CGPA):

I. The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of th number of credits of all the courses undergone by a student, i.e

SGPA (Si) = ∑(Ci x Gi) / ∑ Ci

where Ci is the number of credits of the ith course and Gi is the grade point scored by the student in the ith course.

II. The CGPA IS also calculated In the same manner takmg Into account all the courses undergone by a student over all the semesters of a program, i.e.

CGPA = ∑(Ci x Si) /∑Ci

where Si is the SGPA of the ith semester and Ci is the total number of credits in that semester. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts. Ex. 7.0765 = 7.08 or 6.5168 = 6.52 etc

Transcript (Format): Based on the above recommendations on Letter grades, grade points and SGPA and CCPA, the HEls may issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

Scheme of teaching and examination under semester pattern Choice Based Credit System (CBCS) for M.Sc

Semester I											
Code	Th./Pr.	Teaching Scheme (hrs/week)			CREDITS	Examination Scheme					
		Th.	Pr,	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 1	Paper 1	4	-	4	4	3	80	20	100	40	
Core 2	Paper 2	4	-	4	4	3	80	20	100	40	
Core 3	Paper 3	4	-	4	4	3	80	20	100	40	
Core 4	Paper 4	4	-	4	4	3	80	20	100	40	
Pract. Core 1 &2	Practical 1	-	8	8	4	3-8*	100**	-	100	-	40
Pract. Core 3 &4	Practical 2	-	8	8	4	3-8*	100**	-	100	-	40
Seminar 1	Seminar 1	2	-	2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

Semester II											
Code	Th./Pr.	Teaching Scheme (hrs./week)			CREDITS	Examination Scheme					
		Th.	Pr,	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 5	Paper 5	4	-	4	4	3	80	20	100	40	
Core 6	Paper 6	4	-	4	4	3	80	20	100	40	
Core 7	Paper 7	4	-	4	4	3	80	20	100	40	
Core 8	Paper 8	4	-	4	4	3	80	20	100	40	
Pract. Core 5 &6	Practical 3	-	8	8	4	3-8*	100**	-	100		40
Pract. Core 7 &8	Practical 4	-	8	8	4	3-8*	100**	-	100		40
Seminar 2	Seminar 2	2		2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

Semester III											
Code	Th./Pr.	Teaching Scheme (hrs./week)			CREDITS	Examination Scheme					
		Th.	Pr,	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 9	Paper 9	4	-	4	4	3	80	20	100	40	
Core 10	Paper 10	4	-	4	4	3	80	20	100	40	
Core ele. 1	Paper 11	4	-	4	4	3	80	20	100	40	
Fou. Course 1	Paper 12	4	-	4	4	3	80	20	100	40	
Pract.Core 9 &10	Practical 5	-	8	8	4	3-8*	100**		100		40
Pract. Core ele. 1	Practical 6	-	8	8	4	3-8*	100**		100		40
Seminar 3	Seminar 3	2		2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

Semester IV											
Code	Th./Pr.	Teaching Scheme (hrs./week)			CREDITS	Examination Scheme					
		Th.	Pr,	Tot.		Time (hrs)	Max. Marks		Tot. Marks	Min. Passing Marks	
							Ext. Marks	Int. Marks		Th.	Pr.
Core 11	Paper 13	4	-	4	4	3	80	20	100	40	
Core 12	Paper 14	4	-	4	4	3	80	20	100	40	
Core ele. 2	Paper 15	4	-	4	4	3	80	20	100	40	
Fou. Course 2	Paper 16	4	-	4	4	3	80	20	100	40	
Pract.Core 11 &12 & ele. 2	Practical 7	-	8	8	4	3-8*	100**		100		40
Project	Project	-	8	8	4		100**		100		40
Seminar 4	Seminar 4	2		2	2			50	50	20	
	Total	**18**	**16**	**34**	**26**		**520**	**130**	**650**	**180**	**80**

Note: Th: =Theory; Pr:=Practical/lab, • = If required, for two days. **= The Practical and Project shall be evaluated by both External and Internal Examiner in the respective Department / Center / Affiliated College as per guidelines appended with this direction.

Absorption scheme for failure students of Credit Based Semester Pattern:

a)While switching over to Choice Based Credit System, the failure students of previous credit based semester pattern will be given **Five** chances to clear the examination.

b)The candidates who have cleared first and second semester of Part I of the Credit Based Semester Pattern examination in the concerned subject shall get admission to Third Semester of Part II of the Choice Based Credit System directly. However, candidates who are allowed to keep term will not be eligible for admission to third semester of part II of the Choice BasedCredit System unless they clear all the papers and practical of first and second semester of Part I of the Credit Based Semester Pattern examination.

c)The candidates who have cleared Second and Third semester of Part II of the Credit Based Semester Pattern examination in the concerned subject shall get admission to Fifth Semester of Part III of the Choice Based Credit System directly. However, candidates who are allowed to keep term will not be eligible for admission to Fifth Semester of Part III of the Choice Based Credit System unless they clear all the papers and practical of Third and Fourth semester of Part II of the Credit Based Semester Pattern examination.

Project Work Scheme / Guidelines for the Students, Supervisors and Examiners Every student is required to carry out a project (In lieu of one practical of semester IV of on related topic of the subject / course. The project can be of following types.A) Experimental Project Work; B) Field Based Project Work; C) Review writing based Project Work.

Experimental Project Work and Field Based Project Work:

Student can carry out Experimental/Field Based Project Work on a related research topic of the subject /course. It must be an original work and must indicate some degree of experimental work / Field work. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies at least one month prior to commencement of the final Practical/lab Examination of Semester IV.The project report shall comprise of Introduction, Material and Methods, Results, Discussion, Summary, Conclusions and, References along with the declaration by the candidate that the work is original and not submitted to any University or Organization for award of the degree and certificate by the supervisor and forwarded through Head / Course-coordinator / Director of the Department / Centre or the Principal of the College

Review writing based Project Work.

Student can carry out review writing Based Project Work on a related topic of the subject / course. It must be a review of topic based on research publications. Student shall refer peer reviewed original research publications and based on findings, write a summary of the same. The pattern of review writing shall be based on reputed review publications like :Nature Reviews'. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies at least one month prior to commencement of the final Practical/lab Examination of Semester IV. The project report shall comprise of Abstract, Introduction, Discussion, Summary, Conclusions and, References along with the declaration by the candidate that the work is original and not submitted to any University or Organization for award of the degree and certificate by the supervisor and forwarded through Head / Course-coordinator / Director of the Department / Centre or the Principal of the College.

The supervisors for the Project Work shall be from the following.

A person selected by the duly constituted Selection Committee in the relevant subject and approved by the University, exclusively for P.G. course.

OR

A person selected by the duly constituted Selection Committee in the relevant subject and approved by the University as a full time regular teacher at U.G. level in the relevant subject and having at least 5 years teaching experience with Ph. D. or at least 10 years teaching experience.

OR

Scientists of National Laboratories / Regional Research Laboratories who are approved by dint of their appointments in such facilities by the Union Government / the State Government / Nagpur University / Other Universities recognized by UGC. The topic for the project work shall be assigned to the student by supervisor at the beginning of third semester. The Project Work will carry total 100 marks and will be evaluated by both external and internal examiner in the respective Department / Center / Affiliated College. The examiners will evaluate the Experimental Project Work taking into account the I) Coverage of subject matter, 2) Arrangement and presentation, and 3) References

For written Project work	: 40 Marks - Evaluated jointly by External &Internal
Presentation	: 20 Marks - Evaluated jointly by External &Internal
For Viva-Voce ,', _	: 20 Marks - Evaluated by External examiner
Internal Assessment	: 20 Marks - Evaluated by Internal examiner
Total	: 100 Marks –

General Rules and Regulations regarding pattern of question paper, absorption scheme and choice based credit system

A) Pattern of Question Paper

I. There will be four units in each paper.

2. Question paper will consist of five questions.
3. Four questions will be on four units with internal choice (One question on each unit).

4. Fifth question will be compulsory with questions from each of the four units having equal weightage and there will be no internal choice.
5. Maximum marks of each paper will be 80 (In M. Sc. Mathematics, each paper will be of 100 marks)
6. Each paper will be of 3 hours duration.
7. Projects shall be evaluated by both internal and external examiners.
8. Practical/laboratory examination of 100 marks. Distribution of marks shall be 20 internal and 80 external.
9. Minimum passing marks in each head (theory, practical &project) will be 40%.

Practical Examination

I. Each practical carries 100 marks. For the examination, the distribution of the marks shall be as follows:

a)Record/Journal/Internal assessment : 20 marks - Evaluated by Internal

b)Practical Performance : 60 marks - Evaluated jointly by External &Internal

c)Viva-voce : 20 marks - Evaluated by External

NOTE: Practical performance shall be jointly evaluated by the External and Internal Examiner. In case of discrepancy, The External Examiner's decision shall be final

Internal Assessment:

1.The internal assessment shall be done by the College / University at least 15 days prior to the final examination of each semester. The Marks shall be sent to the University immediately after the Assessment in the prescribed format.

2.For the purpose of internal assessment the University Department / College shall conduct one to three assignments described below. Best two scores of a student in these tests shall be considered to obtain the internal assessment score of that student.

3.General guidelines for Internal Assessment are appended herewith.

a) The internal assessment marks assigned to each theory paper as mentioned in Appendix - A shall be awarded on the basis of assignments like class test, attendance, home assignments, study tour, industrial visits, visit to educational institutions and research organizations, field work, group discussions or any other innovative practice / activity.
b) There shall be one to three assignments (as described above) per Theory paper.
c) There shall be no separate / extra allotment of work load to the teacher concerned. He/ She shall conduct the Internal assessment activity during the regular teaching days / periods as a part of regular teaching activity.
d) The concerned teacher / department / college shall have to keep the record of all the above activities until six months after the declaration of the results of that semester.
e) At the beginning of each semester, every teacher / department / college shall inform his / her students unambiguously the method he / she propose to adopt and the scheme of marking for internal assessment.
f) Teacher shall announce the schedule of activity for. internal assessment in advance in consultation with HOD / Principal.
g) Final submission of internal marks to the University shall be before the commencement of the University Theory / Practical examinations whichever is later.

Appendix 6

Core Elective Paper:

Candidate can opt for anyone core elective paper as shown below in the semester III from anyone core group / specialization group. The same core group / specialization group paper shall be opted in sem IV.

Semester I   Paper 1 (Core 1) Mathematical Physics

Unit I

Curvilinear co-ordinate Systems, Physical ideas about gradient, divergence and Curl, Fourier Series : Definition, Dirichlet's condition, Convergence, Fourier Integral and Fourier transform, Convolution theorem, Parseval's identity, Applications to the solution of differential equations,

Unit II

Elementary ideas about tensors, Cartesian tensors, differential of Cartesian tensors, gradient, divergence and curl , Laplacian of Cartesian tensors. Non-Cartesian tensors.Tensor densities and capacities. Differentiation of Non-Cartesian tensors, Chrisoffel symbols. gradient, divergence and curl , Laplacian of Non-Cartesian tensors

Laplace transform of elementary functions – Inverse Laplace transforms – Methods of finding Inverse Laplace transforms – Heaviside expansion formula – Solutions of simple differential equations

Unit III

Linear vector spaces - linear independent bases, Dimensionality, inner product, matrices, linear transformation, Matrices- Inverse, Orthogonal and Unitary matrices, Cayley Hamilton theorem, eigen vectors and eigen value problem, Diagonalization, Complete orthonormal sets of function.

Unit-IV

Linear differential equations, Special Function- Laguerre, Hermite, Legendre polynomials, Special Bessel's function, Spherical harmonics, Generating Function and recursion relations, differential and integral form.

1.Matrices and Tensor in Physics: A.W.Joshi
2. Mathematical Physics: H.K.Dass
3. Vector analysis – Newell
4. Rajput B S, Mathematical Physics, PragatiPrakashan (Meerat) 1999

Semester I Paper 2 (Core 2) Complex Analysis and Numerical Methods

Unit I

Definition of Complex Numbers, Equality of Complex Number, Complex Algebra, Conjugate Complex Numbers, Geometrical representation of Complex Number, Geometrical representations of the sum, difference, product and quotient of Complex Number, Cauchy-Rieman Conditions, Analytic functions, Multiply connected regions, Cauchy Theorem, Cauchy Integration formula, Derivatives, problems (Rajput – 283 – 314).

Unit II

Singularities- Poles, Branch Points, Calculus of Residues-Residues Theorem, Cauchy Principle value, Pole Expansion of Meromorphic Functions, Product expansion of entire Functions, problems (Rajput 326 – 384).

UNIT III

Methods for determination of zeros and linear and non-linear single variable algebraic and transcendental equations, (Bisection method, false position method, iteration method, Newton-Raphson method, secant method), Finite differences. Newton's formulae (no proofs)

Unit IV

Lagrange's interpolation, Divided differences. Numerical integration, trapezoid rule, simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, Linear least squares.

Euler and RungeKutta methods for solving ordinary differential equations. (No proofs)

References:

1. Rajput B S, Mathematical Physics, PragatiPrakashan (Meerat) 1999
2. Introductory Methods of Numerical Analysis: S SSastry
3. Computer Oriented Numerical Methods: V Rajaraman
4. R. V. Churchill, Complex variables and Applications, 7th Edition McGraw Hill
5. Computer oriented Numerical Methods: R.S.Salaria
6. Mathematical Physics: H.K.Dass
7. Higher Engineering Mathematics : B. S. Grewal

<u>**Semester I Paper 3 (Core 3) Electronics**</u>

Unit I

Electronics Semiconductor discrete devices (characteristic curves and physics of p-n junction), Schottky, Tunnel and MOS diodes, Bipolar junction transistor, junction field effect transistor (JFET),Metal-oxide-Semiconductor Field effect transistor (MOSFET), unijunction transistor(UJT) and sillicon controlled rectifier (SCR), Opto-electronic devices (Photo-diode, solar cell, LED, LCD and photo transistor), Diffusion of impurities insillicon, growth of oxide.

Unit II

Applications of semiconductor devices in linear and digital circuits- Zener regulated power supply, Transistor (bipolar, MOSFFT, JFET) as amplifier, coupling of amplifier stages (DC, RC and Transformer coupling), RC-coupled amplifier, dc and power amplifier Feedback in amplifiers and oscillators (phase shift, Hartley, Colpitts and crystal controlled) clipping and clamping circuits. Transistor as a switch OR, AND and NOT gates (TIL and CMOS gates).

Unit III

Digital integrated circuits- NAND and NOR gates building block, X-OR gate, simple combinational Circuits -Half and full address, Flip-Flops, Multivibrators (using transistor) and sweep geneator (using transistors, UJT and SCR). shift registers, counters, A/D and D/A coverters, semiconductor memories (ROM, RAM, and EPROM, basic, architecture of 8 bit microprocessor (INTEL 8085). Linear integrated circuits-Operational amplifier and its applications-Inverting and noninverting amplifier, adder, integrator, differentiator, waveform generator, comparator and Schmittrigger, Butterwoth active filter, phase shifter,

Unit IV

Communication Electronics-Basic principle of amplitude frequency and phase modulation. Simple circuits for amplitude modulation and demodulation, digital (PCM) modulation and demodulation. Fundamentals of optical communication, Microwave Oscillators (reflex, klystron, megnetron and Gunn diode), Cavity resonaters. Standing wave detector.

Textbooks:

1. A. Malvino and D. J. Bates: Electronic Principles (Mc Graw Hill Education, India)
2. Boylstad&Neshishkey, “Electronic devices & circuits” , PHI
3. Milliman, J. Halkias, “integrated elctronics”, Tata McGraw Hill
4. J. J. CatheySchaum’s Outlines “Electronic Devices & Circuits” Tata McGraw Hill.
5. J. D. Ryder,” Electronics Fundamentals and Applications”, John Wiley-Eastern Publications.
6. A. P. Malvino, D.P. Leach, “Digital Principles and Applications”, McGraw Hill Book Co., 4th Edition (1986).
7. Ramakant A. Gayakwad, “Op-amps and Linear Integrated Circuits” PHI
8. Anil Maini, Varsha Agrawal, “ Electronic Devices and acircuits” Wiley
9. George Kennedy, “ Electronic Communication Systems”, Tata McGraw Hill.
10. Dennis Roddy, John Coolen, “Electronic Communication Systems ”, Pearson.

Semester I   Paper 4 (Core 4) Electrodynamics I

Unit I

Electrostatics: Coloumb's law, Electric field, Charge distribution, Dirac delta function, Field lines, Gauss's law and applications, Differential form of Gauss's law, Electric potential, Poisson and Laplace's equations, Electrostatic potential energy.

Unit II

Electrostatics: Boundary value problems, Uniqueness theorems, Green's theorem, Method of images, Method of separation of variables (Cartesian Coordinates, Spherical and Cylindrical Coordinates), Multipole expansion.

Unit III

Magnetostatics: Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, magnetic moment, Magnetostatics boundary conditions, Magnetic Shielding.

Unit IV

Time varying fields: Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials, Gauge Transformation, Wave equations, Poynting's theorem, Conservation laws.

Text Books:

1.Introduction to Electrodynamics, David J. Griffith, Prentice Hall of India Private Limited.
2. Classical Electrodynamics, John D. Jackson, Wiley Eastern Limited.
3. Classical Electrodynamics, Tung Tsang, World Scientific Publishing Private Limited.

Semester I   Practical 1 and 2

Practical 1 (core 1 and 2)

1. To find the largest or smallest of a given set of numbers.
2. Bubble sort.
3. To generate and print first hundred prime numbers.
4. Matrix multiplication.
5. To generate and print an odd ordered magic square.
6. Other exercises involving conditions, loop and array
7. Lagrange Interpolation.
8. Method of successive approximation
9. Bisection Method
10. Newton-Raphson Method.
11. Gaussian Elimination
12. Linear Least Squares Fit.
13. Simpson's rule integration.
14. Computation of special functions

Practical 2 (Core 3 and 4)

1. Design of a regulated power supply.
2. Characteristics and applications of silicon controlled rectifier.
3. Design of common emitter Power transistor amplifier.
4. Experiments on bias stability.
5. Negative feedback (Voltage series / shunt and current series / shunt).
6. Astable, Monostable and Bistablemultivibrator.
7. Experiment on FET and MOSFET characterization and application as an
8. amplifier.
9. Experiment on Uni-junction transistor and its application.
10. Digital – I: Basic, TTL, NAND and NOR.
11. Digital – II: Combinational logic.
12. Flip-Flops.
13. Study of modulation (FM, AM, etc.).
14. Operational Amplifier.
15. Differential Amplifier.
16. Microprocessor.
17. Verification of Biot-Savart law.
18. Verification of Faraday’s Law

Semester II Paper 5 (Core 5) Quantum Mechanics I

Unit- I

Time dependent and time-independent Schrodinger equation, continuity equation, wave packet, admissible wave functions, stationary states.

Formalism of wave mechanics, expectation values, quantum mechanical operators for position and momentum in the coordinate representation, Construction of quantum mechanical operators for other dynamical variables from those of position and momentum, Ehrenfest's theorem, momentum eigen functions in the coordinate representation, box normalization and Dirac delta function.

Coordinate and momentum representations, Schrodinger equation in momentum representation,

Unit-II

Brief revision of linear vector spaces, inner or scalar product, Schwarz inequality, state vectors, general formalism of operator mechanics vector, operator algebra, commutation relations, eigen values and eigen vectors, hermitian operators degeneracy, orthogonality eigenvectors of Hermitian operators, noncommutativity of two operators and uncertainty in the simultaneous measurements of the corresponding dynamical variables, the fundamental expansion postulate, representation of state vector, Dirac's bra-ket notations.

Matrix representation of operators, change of basis, unitary transformations,

quantum dynamics, Schrodinger, Heisenberg and interaction picture.

Unit-III

Solution of Schrodinger equation for simple problems, 1-D Square well, step and barrier potentials, 1-D harmonic oscillator, zero point energy. harmonic oscillator problem by operator method.

Angular momentum operator, commutation relations, expression for L^2 operator in spherical polar coordinates, Role of L^2 operators in central force problem, eigen value problem for L^2 , separation of Schrodinger equation in radial and angular parts, solution of radial equation for hydrogen atom, 3-d square well potential, parity of wave function, parity operator.

Unit-IV

Generalized angular momentum, raising and lowering operators, matrices for J^2, Jx, Jy, Jzoperators,Pauli spin matrices, Addition of angular momenta, Clebich-Gordon Co-efficient, spin angular momentum, spin momentum functions.

Text and Reference Books:

1. Quantum mechanics: E. Merzbacher
2. Quantum mechanics: L.I.Schiff
3. Quantum mechanics: Mathews and Venkatesan
4. Quantum mechanics :Ghatak and Loknathan
5. Quantum mechanics: B.Craseman and J.D.Powell
6. Modern quantum mechanics: J.J.Sakurai
7. Quantum Theory D. Bohm, (Asia Publishing House)
8. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)

Semester II   Paper 6 (Core 6) Statistical Physics

Unit I

Fundamentals of classical statistical mechanics, microstate and macrostate, distribution function, Liouville's theorem, Gibbs Paradox, ensembles (micro-canonical, canonical and grand-canonical), partition function, free energy and connection with thermodynamic quantities, energy and density fluctuations

Unit II

Fundamentals of quantum statistical mechanics, BE and FD Statistics, Symmetry of wave functions, Boltzmann limit of Bosons and Fermions, Ideal Bose system: Bose-Einstein condensation, Behaviour of ideal Bose gas below and above Bose temperature, Photons and liquid helium as bosons.

Unit III

Ideal Fermi system: Weak and strong degeneracy, Fermi function, Fermi energy, Behaviour of ideal Fermi gas at absolute zero and below Fermi temperature, Fermionic condensation, Free electrons in metals as fermions, Electronic specific heat,
Cluster expansion for classical gas, Virial equations of states.

Unit IV

Phase transition: Phase transition of first and second order, Landau theory of phase transition, Ising model, Order parameter, Critical exponents, Scaling hypothesis, Random walk, Brownian motion, Langevin theory, Correlation function and fluctuation-dissipation theorem, Fokker-Planck equation. Weiss theory of ferromagnetism.

Text and Reference Books:

1. Fundamentals of Statistical Physics: B. B. Laud
2. Statistical Mechanics: R. K. Pathria
3. Statistical Mechanics: S. K. Sinha
4. Statistical and Thermal Physics: F. Reif
5. Statistical Mechanics: K. Huang
6. Statistical Mechanics: Loknathan and Gambhir
7. Statistical mechanics: R. Kubo
8. Statistical Physics: Landau and Lifshitz

Semester II Paper 7 (Core 7) Classical Mechanics

Unit-I

Survey of elementary principles of mechanics of a particle, Dynamical systems, Phase space dynamics, stability analysis, constraints & their classifications, D'Alemberts Principle, Variational Principle, Lagrange's equation, Hamilton's Principle

Unit-II

Conservation theorems and symmetry properties, Hamiltonian formalism, Hamiltons equations, Routh's procedure for cyclic coordinates, conservation laws
Canonical transformations, Poisson brackets and Poisson theorems, Hamilton-Jacobi Theory

Unit-III

Central force motion, reduction to one body problem, equations of motions and first integrals , classification of orbits for inverse square central forces. Two body collisions, Rutherford scattering in laboratory and centre-of-mass frames;

Unit-IV

Rigid body dynamics, Euler's angles, Euler's theorem, moment of inertia tensor, eigen values and principal axis transformation, non-inertial frames and Pseudo forces, Periodic motion,: small oscillations, normal modes.

Text and Reference books:

1. Classical Mechanics: H. Goldstein
2. Classical Mechanics: N.C.Rana and P.S.Joag
3. Classical Mechanics : J. C. Upadhyaya (Himalaya Publishing House)

Semester II Paper 8 (Core 8) Electrodynamics II

Unit-I

Scalar waves : Plane waves, spherical waves, phase and group velocities and wave packets Vector waves : Electromagnetic plane waves, harmonic plane waves, elliptic linear and circular polarization, Stokes parameters (iii) Reflection and refraction of plane waves, Fresnel polarization on reflection and refraction, (iv) Propagation in dielectric films.

Unit-II

Symmetries of Maxwell equations : Lorentz transformations, Covariance of electrodynamics, Lorentz gauge condition, equation of continuity and Maxwell equations, electrodynamics field tensor and its transformation. Relativistic field theory, Lagrangian for EM field conservation laws, conformal invariance.

Unit-III

Motion of a charge in EM fields : Lorentz force, motion in uniform, static, electric and magnetic fields and combined static EM fields.

The wave equation : Electric dipole, electric quadrupole and magnetic dipole radiation, half wave and full wave antenna. Radiation by a moving charge :Lienard-Wiechert potentials of a point charge, Larmor's formula, Angular distribution of radiation.

Unit-IV

Wave guides : Cylindrical cavities, fields on the surface and within a hollow metallic conductor,TE, TM, TEM modes in a rectangular and cylindrical wave guide, fields and radiation of a localized oscillating source, electric dipole, magnetic dipole and electric quadrupole fields. Bremsstarhlung : virtual quanta, synchrotron radiation.

Reference Books

1.Introduction to Electrodynamics: David Griffiths (PHI)
2. Electrodyanamics J. D. Jackson
3. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa)
4. Classical theory of fields, Landau &Lifshitz
5. Electrodynamics, W. Panofsky and M. Phillips
6. Principles of Optics, M. Born & E. Wolf Pergamon Press
7. Electromagnetism and Classified Theory, A. D. Barut, Dover

Semester II   Practical 3 and 4

Practical 3 (C5 and C6)

1. Study of B-H Curve
2. Determination of e/m of electron by normal Zeeman effect using Febry Perot Etalon.
3. Determination of Lande's factor of DPPH using ESR spectrometer
4. Determination of e/m by Thomson method.
5. Determination of e/m by Busch's helical beam method.
6. Study of paramagnetic to ferromagnetic phase transition.
7. Study of Paramagnetic salt by Guoy's balance
8. Differential scanning Calorimetry
9. Determination of Plank's constant.
10. Determination of Stephan's constant.
11. Simulation of Ising model.
12. Location of critical point in Ising model using Binder cumulant.
13. Simulation of random walk.
14. Simulation of mean field model of para-ferro transition.
15. Numerical solution of particle in a box.
16. Simulation of Maxwell's velocity distribution.

Practical 4 (core 7 and 8)

1.Study of Focault pendulum
2.Study of Bifilar pendulum
3.Fibre optics
4.Study of waveguide
5.Thickness of thin wire with lasers
6.Measurement of wavelength of He-ne laser light using ruler.
7.To study Faraday effect using He-Ne laser.
8.Simulation of simple pendulum
9.Simulation of compound pendulum
10. Simulation of planetary motion.

Semester III Paper 9 (Core 9) Quantum Mechanics II

Unit- I

Time independent perturbation theory, First order perturbation theory applied to non-degenerate states, second order perturbation extension to degenerate state, Application of perturbation theory to the ground state energy, He atom (calculation given in Pauling and Wilson), Normal and anomalous Zeeman effect, First order Stark effect in the ground and first excited states of H atom and second order Stark effect of H atom, an-harmonic oscillator.

Unit II

Time dependent perturbation theory, transition rate, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption and induced emission, atomic radiation, dipole approximation, Einstein's atomic radiation, Einstein's A and b coefficients and their calculations.

Approximation methods: W. K. B. method and its application to barrier penetration.

Variational principle and its application to simple cases like ground state of He atom and deuteron in Yukawa potential.

Unit III

System of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions for a system of non-interacting particles, statistics of systems of identical particles, Relation of statistics with spin, Ortho and para states of the helium atom and their perturbation by Coulomb repulsion.

Hamiltonian of a molecule, Born-Oppenheimer approximation, outline of Heitler-London theory of the hydrogen molecule.

Scattering theory, scattering cross-section in laboratory and centre of mass system, scattering by a central potential, Partial wave method, phase shifts and their importance, scattering by a square well potential and a perfectly rigid sphere, resonance scattering.

Unit IV

Relativistic wave equation, the Klein-Gordon equation and initial difficulties in interpreting its solutions, Dirac's relativistic equation, Dirac's matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic field and explanation of the magnetic moment due to the electron spin, spin-orbit interaction, solution for hydrogen atom in Dirac's theory, negative energy states and their qualitative explanations.

Text and References Books:

1. E. Merzbacher, Quantum Mechanics (Wiley and Sons-Toppon)
2. J. L. Powell and B. Crasemann, Quantum mechanics (B I Publications)
3. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
4. Quantum Mechanics: Aruldhas
5. Pauling and Wilson, Introduction to Quantum Mechanics
6. A.K. Ghatak and Lokanathan, Quantum Mechanics (Macmillan, India)
7. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)

Semester III Paper 10 (Core 10) Solid State Physics and Sprectroscopy

Unit I: Order in Solids-Crystal classes and system, 2d and 3d lattices, Space groups, b Concept of point group, bonding of common crystal structure; reciprocal lattice, diffraction and structure factor, Miller and Bravais indices, Bonding, diffraction and structure factor in solids, short and long range order in liquids and solids, liquid crystals, quasicrystals and glasses

Unit II

Defects: Vacancies, Point defects, line defects and stacking faults, Burgers vector and Burger circuit, presence of dislocation, dislocation motion, perfect and imperfect dislocations, slip planes and slip directions, dislocation reactions

Dielectric Properties: -Polarization mechanisms, Clausius-Mossotti equation, piezo, pyro and ferroelectricity

Unit III

Atomic Structure and Atomic Spectra : Quantum states of an electron in an atom. Electron spin.Spectrum of helium and alkali atom. Some features of one-electron and two electron atoms, Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Inner shell vacancy, X-rays and Auger transitions.chemical shift. Frank-Condon principle.

Unit IV

Molecular Structure and Molecular Spectra : Types of molecules, Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Morse potential energy curve, Molecules as vibrating rotator, Vibration spectrum of diatomic molecule, PQR branches. Elementary discussion of Raman, ESR and NMR spectroscopy, chemical shift

Reference Books: 1. Physics of Atoms and Molecules: Bransden and Joachain.
2. Introduction to Atomic Spectra: H.E. White.
3. Solid State Physics, Charles Kittel, John Willey & Sons
4. Molecular Spectra and Molecular Spectroscopy (Vol. 1), G. Herzberg
5. Introduction to Atomic Spectra: HG Kuhn
6. Fundamentals of molecular spectroscopy, C.B. Banwell
7. Introduction to molecular Spectroscopy , G. M. Barrow
8. Introduction to Solid State Physics: C. Kittle
9. Materials Science and Engineering: V. Raghavan
10. Solid State Physics: S. O. Pillai (New Age International 2006)
11. Ferroelectricity Jona and Shirane

Semester III   Practical 5

Practical 5 (Core 9 and Core 10).

1.Determination of ionization potential of lithium

2.X-ray diffraction by TELEXOMETER.

3.Study of emission spectra of iron (Iron arc).

4.Determination of Dissociation Energy of Iodine Molecule by photography of the absorption band of Iodine in the visible region.

5.Study of Stark effect

6.Study of Molecular Spectra

7.Determination of Rydberg's constant

8.Determination of Plank's constant

9. Study of Crystals

10. Study of line spectra

Semester III Paper 11 (Core Elective E1.1) Materials Science I

Unit- I

Equilibrium and kinetics: Stability and metastability, Basic thermodynamic functions, Statistical nature of entropy, Kinetics of thermally activated process.

Phase diagrams: The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system (water), two component system containing two phases and three phases, Binary phase diagrams having intermediate phases, Binary phase diagrams with eutectic system. Lever principle, maximum, minimum, super lattice, miscibility gap, microstructure changes during cooling, application to zone refining.

Unit – II

Phase transformations: Time scale for phase changes, peritectic reaction, eutectoid and eutectic transformations, order disorder transformation, transformation diagrams, dendritic structure in alloys, transformation on heating and cooling, grain size effect on rate of transformation at constant temperature and on continuous cooling, grain size effect on rate of transformation, nucleation kinetics, growth kinetics, interface kinetics leading to the crystal growth.

Unit-III

Diffusion in solids: Fick's laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion co-efficient, self diffusion, interstitial diffusion, the Snoek effect in diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice, thermal vibrations and activation energy, diffusion of carbon in iron.

Solid State Ionics: Definition, classification and characteristic properties of solid electrolytes. Complex impedance spectroscopy, Arrhenius theory of ionic conductivity. Chemical sensors: Nernst equation, potentiometer and amperometric sensors for various gases, electrochemical redox-reaction, advantages of electrochemical sensors.

UNIT-IV

Solid state energy devices: Fundamental of Solar cells, Primary and secondary solid state cells, advantages of lithium batteries, ion intercalation compounds for secondary cell, open circuit voltage and short circuit current, intercalation compounds for secondary cell, open circuit voltage and short circuit current, Energy density, power density. Fuel cells –advantages and disadvantages, classification, efficiency- emf of fuel cells, hydrogen/oxygen fuel cell, criteria for the selection electrode and electrolyte, methanol fuel cell, solid oxide fuel cells, phosphoric acid fuel cells, molten carbonate fuel cell, proton exchange membrane fuel cell, biochemical fuel cell.

Text and Reference books:

1. Vanvellak: Materials Science.
2. V. Raghvan: Materials Science.
3. D. Kingery: Introduction to ceramics.
4. R. E. Reedhil: Physical metallurgy.
5. Martin Start Sharger: Introductory materials.
6. Sinnot: Solid state for engineers.
7. Kelly and Groves: Crystal and defects.
8. Kittel: Solid state physics, Vth edition.
9. M. A. Azaroff: Elements of crystallography
9. Introduction to solid state theory: Modelung.
10. Fuel Cells – A. Mcdougall, Macmillan 1976 Ch 3,5,7,8 and 11.

Semester III Paper 11 (Core Elective E1.2) X-ray I

Unit I

Production of X-rays: Continuous and characteristic X-ray spectra. X-ray emission from thick and thin targets. Efficiency of X-ray production.Various types of demountable and sealed X-ray tubes.

Basics of high-tension circuits and vacuum systems used for the operation of X-ray tubes.

Synchrotron radiation: Production and properties of radiation from storage rings, Insertion devices.

Unit II

Absorption of X-rays: Physical process of X-ray absorption. Measurement of X-ray absorption coefficients.Units of dose and intensity.Radiography, Microradiography and their applications.

X–ray fluorescence: Fluorescence yield. Auger effect.X–ray fluorescence analysis and its applications.Techniques and applications of Photoelectron spectroscopy and Auger electron spectroscopy.

Unit III

X-ray spectroscopy: Experimental techniques of wavelength and energy dispersive x-ray spectroscopy.

Bragg and double crystal spectrographs.Focusing spectrographs.Dispersion and resolving power of spectrographs, Photographic and other methods of detection, resolving power of detectors.

X–ray emission and absorption spectra.Energy level diagram. Dipole and forbidden lines, Satellite lines and their origin, Regular and irregular doublets. Relative intensities of X-ray lines.

Unit IV

Chemical Effects in X-ray Spectra: Chemical effects in X-ray spectra. White line, Chemical Shifts of absorption edges, Fine structures (XANES and EXAFS) associated with the absorption edges and their applications.

Dispersion Theory: Dispersion theory applied to X-rays, Calculation of the dielectric constant, Significance of the complex dielectric constant, Refraction of X-rays, Methods for measurement of refractive index

Text and Reference Books:

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment
2. J. A. Nielsen and D. Mc. Morrow: elements of Modern X-ray Physics.
3. M. A. Blokhin: X-ray Spectroscopy.
4. E. P. Bertin: Principles and Practice of X-ray Spectrometric Analysis.
5. C. Bonnelle and C. Mande: Advances in X-ray Spectroscopy.
6. D. C. Koningsberger and R. Prins: X-ray Absorption Principles, Applications, Techniques of EXAFS, SEXAFS and XANES.
7. C. Kunz: Synchrotron Radiation.

Semester III Paper 11 (Core Elective E1.3) Nanoscience and Nanotechnology I

Unit I:

Introduction to Nanoscience:

Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Structure property relation, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation on Raman spectra of nano-materials.

Unit II:

Synthesis of Nanomaterials:

Physical methods**:** High energy Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser ablation, Laser pyrolysis, Sputter deposition, Electric arc deposition, Photolithography.

Chemical methods**:** Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Microemulsions, Sol-gel method, Combustion method, Wet chemical method

Unit III:

Nanomaterials Characterizations:

X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Scanning Tunnelling Electron Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer, Spintronics

Unit IV:

Special Nanomaterials and Properties:

Carbon nanotubes, Porous silicon, Aerogels, Core shell structures. Self assembled nanomaterials. Metal and semiconductor nanoclusters

Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties of nanomaterials

Text and Reference books:

1. Nanotechnology: Principles &Practicals. Sulbha K. Kulkarni ,Capital Publishing Co.New Delhi.

2. Nanostructures & Nanomaterials Synthesis, Properties & Applications**.** Guozhong Cao, Imperials College Press London.

3.Nanomaterials: Synthesis, Properties & Applications**.** Edited by A.S. Edelstein &R.C.Commorata.Institute of Physics Publishing, Bristol & Philadelphia.

4. Introduction to Nanotechnology. C.P. Poole Jr. and F. J.Owens, Wiley Student ed.

5. Nano: The Essentials. T.Pradeep , McGraw Hill Education.

6. Handbook of Nanostructures: Materials and Nanotechnology. H. S. Nalwa Vol 1- 5, Academic Press, Bostan.

7. Hand Book of Nanotechnology, Bhushan

8. Nanoscience and Technology: Novel Structure and Phenomena. Ping and Sheng

Semester III   Paper 11 (Core Elective E1.4) Atomic and Molecular Physics I

Unit I

Quantum states of an electron in an atomic Electron spin, spectrum of hydrogen, Helium and alkali atoms, Relativistic corrections for energy levels of hydrogen; Basic principles of interaction of spin and applied magnetic field.

Concepts of NMR spectroscopy concepts of spin-spin and spin-lattice relaxation, chemical shift; spin-spin coupling between two and more nuclei; chemical analysis using NMR.

Mossbauer effect-Recoil less emission of gamma rays, chemical shieft, magnetic hyperfine interaction,

Unit II

electron spin resonance, experimental setup, hyperfine structure and isotopic shift,width of spectral lines, LS & JJ coupling, Zeeman, Paschen Back & Stark effect. Spontaneous and Stimulated emission, Einstein A & B Coefficients; LASERS, optical pumping, population inversion, rate equation, modes of resonators and coherence length, Role of resonant cavity, three and four level systems, Ammonia MASER, ruby, He-Ne, $CO2$, dye and diode lasers, Lasers applications

Unit III

Rotational, vibrational and Raman spectra of diatomic molecules, Quantum theory, Molecular polarizability, Intensity alteration in Raman spectra of diatomic molecules, Experimental setup for Raman spectroscopy in the structure determination of simple molecules. polyatomic molecules, symmetric top asymmetric top molecules. Hunds rule.

Unit IV

Electronic spectra of diatomic molecules, Born Oppenheimer approximation, Vibrational Coarse structure of electronic bands, intensity of electronic bonds, Franck Condon principle, and selection rules,dissociation and pre dissociation, dissociation energy, rotational fine structure of electronic bands. General treatment of molecular orbitals, Hund's coupling cases.

Text Book and References:

1. Molecular Spectroscopy: - Jeane L. McHale.
2. Mossbauer spectroscopy –M. R. Bhide.
3. NMR and Chemistry – J. W. Akitt.
4. Structural Methods in inorganic chemistry, E.A V.Ebsworth, D. W. H.Rankin, S.Crdock.
5. Introduction to Atomic Spectra – H. E. White.
6. Fundamental of Molecular Spectroscopy – C. B. Banwell.
7. Spectroscopy Vol. I, II and III, Walker and Straghen.
8. Introduction to Molecular Spectroscopy – G. M. Barrow.
9. Spectra of diatomic molecules – Herzberg.
10. Molecular spectroscopy – Jeanne L. McHale.
11. Molecular spectroscopy – J. M. Brown.
12. Spectra of Atoms and Molecules – P. F. Bemath.
13. Modern Spectroscopy – J. M. Holkas.
14. Laser spectroscopy and instrumentation- Demtroder

Semester III Paper 11 (Core Elective E1.5) Applied Electronics I

Unit – I

Operational Amplifiers, Block diagram of a typical operational amplifier, analysis, open loop configuration, inverting and non-inverting amplifiers, operational amplifier with negative feedback,voltage series feedback, effect of feedback on close loop gain, input resistance output resistance bandwidth and output offset voltage, voltage follower. Practical operational amplifier, input offset voltage, input bias current, input off set current, total output off set voltage, CMRR, frequency response, dc and ac amplifier, summing, scaling and averaging amplifier, instrumentation amplifier, integrator and differentiator.Application of Op-Amp as fixed and variable voltage regulator. Oscillators principles- Barkhausen criterion for oscillations, The phase shift oscillator, Weinbridge oscillator, LC tunable oscillator, multi-vibrators, mono-stable and astable, comparators, square wave and triangular wave generators

UNIT II

Communication electronics: Amplitude modulation , generation of AM waves, demodulation of AM waves, DS BSC modulation, generation of DSBSC waves, coherent detection DSBSC wave, SSB modulation, generation and detection of SSB waves, Vestigial sideband modulation, frequency division multiplexing (FDM).

Microwave communication: Advantage and disadvantage of microwave transmission, loss in free space propagation of microwaves, atmospheric effect on propagation, Fresnel zone problem, ground refection,fading sources, detector components, antennas used in microwave communication systems

Unit – III

Microprocessor: Introduction to microcomputers, Memory. Input-output devices, interfacing devices.8085 CPU, architecture, bus timing, de-multiplexing, the address bus, generating control signals,instruction set, addressing modes, illustrative programmes, assembly language programmes, looping, counting and indexing, counters and timing delay, stack and sub routings. read only memory (ROM) and applications. Random access memory (RAM) and applications,

Digital to analogue converters. Ladder and weighted register types, analog to digital converters, ,successive approximations and dual slop converters, application of DAC and ADC,

Unit – IV

Microwave devices: Klystrons, magnetrons, and travelling wave tubes, velocity modulation, basic principle of two cavity klystrons and reflex klystrons, principle of operation of magnetrons, Helix travelling wave tubes, wave modes, transferred electron devices, gunn effect, principle of operation,modes of operation, read diode, IMPATT diode, TRAPATT diode..

Text and Reference Books:

1. Electronic devices and circuit theory: RobortBoylested and L. Nashdsky (PHI, New Delhi).
2. OP-Amps and linear integrated circuits: Ramakanth A. Gayakwad (PHI 2nd Edn).
3. Digital principles and Applications: A. P. Malvino and D. P. Leach (Tata Ma-Graw Hill).
4. Microprocessor architecture, programming and Application with 8085/8086, Ramesh S. Gaonkar(Wiley-Estern).
5. Microelectronics: Jacob Millman (Mc-Graw Hill International).

6. Optoelectronics: Theory and Practices: Edited by Alien Chappal (Mc Graw Hill).
7. Microwaves: K. L. Gupta (Wiley Ester New Delhi).
8. Advanced electronics communication systems: Wayne Tomasi (Phi Edn).
9. Fundamentals of microprocessors and Micro-computers: B. Ram. (Dhanpat Rao and Sons.).

Semester III Paper 11 (Core Elective E1.6) Methods of Theoretical Physics I

Mathematical and Computational Methods:

Unit 1

Definition of groups, subgroups and conjugate classes - Symmetry elements, Transformation, Matrix representation - Point groups - representation of a group - Reducible and irreducible representations - Orthogonality theorem - character of a representation - character Table C2v and C3v - Application to Infrared and Raman active vibrations of XY3 type molecules - Projection operators applied to an equilateral triangle - Rotation group and angular momenta.

Unit 2

Elements of C Programming Language: Algorithms and flowchart; Structure of a high level language program; Features of C language; constants and variables; expressions; Input and output statements; conditional statements and loop statements; arrays; functions; character strings; structures; pointer data type; list and trees.

Unit 3

Partial Differential equations in Physics, Discretization of equation, matrix method relaxation method, groundwater dynamics, initial value problems, temperature field of nuclear waste rod (Peng)

Unit 4

Generation of uniformly distributed random integers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method, Metropolis algorithm, Brownian Motion and Ising model in 2 dimensions.

References

1. A Guide to Monte Carlo Simulations in Statistical Physics - D.P. Landau and K. Binder, (Cambridge University Press (2000))
2. Mathematical methods for physicists- G.B. Arfkenand ,H.T.Weber
3. A.W. Joshi, 1997, Elements of group Theory for Physicists, 4th Edition, New Age International, New Delhi.
4. F.A. Cotton, Chemical Application of Group Theory 3rd Edition, John Wiley and Sons, New York.
5. Let us C : Y Kanetkar
6. A First Course in Computational Physics - P.L. DeVries (Wiley).
7. Computer Applications in Physics - S.Chandra (Narosa)
8. Computational Physics - R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age)
9. Computational physics by S.F. Koonin (Addition – Wesley , NY) 1986
10. An introduction to computer simulationmethod PART – I (Addition – Wesley , NY) , 1998 by Gould and J. Tebochaik
11. An introduction to compulation physics by Tao Pang.(Cambridge Univ-Press, 1997)
12. A physicist’s guide to Mathemetica by P.T. Tam (Academic Press, II Edition)

Semester III   Paper 11 (Core Elective E1.7) Nonlinear Dynamics I

Unit I

Flows on a line, fixed points and their stability, Population growth, Linear Stability Analysis, Existence and Uniqueness, Impossibility of Oscillations, Potentials, Bifurcations, Saddlenode, Transcritical, Pitchfork, Examples, Imperfect Bifurcation. (Chapter 2 and 3 of Ref. 1)

Unit II

Flows on a circle, Uniform and Nonuniform Oscillator, Over damped Pendulum, Superconducting Josephson Junction, Fireflies, Examples of Linear System, Classification of Linear System. (Chapter 4 and 5 of Ref. 1)

Unit III

Phase portraits, Existence and Uniqueness, Fixed points and their Linearization, Conservative Systems, Reversible Systems, Index theory, Limit Cycles, Ruling out Closed Cycles, Poincare-Benedixon theorem, Lienard Systems, Relaxation Oscillations, Weakly Nonlinear Oscillators. (Chapter 6 and 7 Ref. 1)

Unit IV

Bifurcations in detail, Saddle-node, transcritical, pitchfork, Hopf, Global Bifurcations, Hysteresis in Driven pendulum, Coupled Oscillators and Quasiperiodicity (Chapter 8 of Ref. 1)

Reference books:

1. S. W. Strogatz : Nonlinear Dynamics with Applications to Physics, Biology, Chemistry and Engineering. (Perseus)
2. Edward Ott : Chaos in Dynamical Systems (Cambridge University Press)

Semester III Practical 6 and 7 for elective papers

Practical 6 (elective)
Materials Science

1. Crystal structure determination by powder diffraction.
2. Study of microstructures of metal alloys.
3. Dislocation in alkali halide crystals.
4. Crystal growth from slow cooling of the melt.
5. Thermal analysis of binary alloy.
6. Differential thermal analysis of BaTiO3-PbTiO3 solid solution.
7. To study electrochemical method of corrosion control.
8. Dielectric behaviour of LiNbO3 and BaTiO3 in crystals and ceramics.
9. Electrical conductivity of ionic solids.
10. To test hardness of a material by Brinell hardness tester.
11. Photo elasticity study.
12. Multiple beam interferromentric study of surfaces.
13. Thermal conductivity of bad conductor. 14. Thermal expansion coefficient of metals.
15. Study of transport property in solid electrolytes.
16. Verification Nernst law/Oxygen sensor.
17. Determination of Thermoelectricity Power.

X-Rays

1. Study of Crystal Models.
2. X-ray Diffraction Photograph of a Metal Foil by transmission (Hull Method).
3. X-ray Diffraction Photograph of a Metal Foil by Back Reflection.
4. Powder Photograph by Debye Scherrer Method, Computer Analysis.
5. Laue Photograph and Gnomonic Projection.
6. Rotation oscillation Photograph.
7. Diffraction of X-rays by Liquids.
8. Bragg's Spectrometer: Uhler and Cooksey's method. 55
9. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L Absorption Edges.
10. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L emission Spectra.
11. Measurement of Intensities of Emission Lines, Computer Analysis.
12. Study of Satellite Lines. 13. Analysis of XANES Spectrum, Computer Analysis.
14. Analysis of EXAFS Spectrum, Computer Analysis.
15. Determination of Planck's constant by X-rays.
16. X-ray Fluorescence Spectrum Analysis.
17. Absorption Coefficient for X-rays by G. M. / Scintillation Counter.
18. Characteristics of G. M. tube.
19. Compton Effect.
20. Operation of a Demountable X-ray Tube.

Nanoscience and Nanotechnology

1. Synthesis of metal oxide nanoparticles by wet chemical method.
2. Deposition of thin films by spray pyrolysis technique.
3. Synthesis of inorganic nanomaterials by combustion method.

4. Synthesis of nanomaterials by sol-gel method.
5. Synthesis of conducting polymer nanofibres by chemical oxidation method.
6. Study of optical absorption of nanoparticles.
7. Determination of particle size of nanomaterials from x-ray diffraction.
8. Study of photoluminescence of well known luminescent nanoparticles.
9. Deposition of thin films by spin coating method.
10. Thermoluminescence study of nanomaterials.
11. Deposition of thin films by dip coating technique.
12. Study of particle size effect on luminescence.
13. Electrical characterization of nanostructured materials.
14. Synthesis of metal oxide nanoparticles by hydro-thermal method.
15. Deposition of thin film in vacuum.
16. Electrical resistivity of nanomaterials using four probe method
17. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
18. Characterization of nanomaterials using SEM/TEM.
19. Computer modelling methods for studying materials on a wide variety of length and time scales.

Atomic and Molecular Physics

1. Study of line spectra on photographed plates/films and calculation of plate factor.
2. Verification of Hartman's dispersion formula.
3. Study of sharp and diffuse series of potassium atom and calculation of spin orbit interaction constant.
4. Determination of metallic element in a given inorganic salt.
5. To record the spectrum of CN violet bands and to perform vibrational analysis.
6. To record the visible bands of ALO and to perform vibrational analysis.
7. To photograph and analyse the reddish glow discharge in air under moderate pressure.
8. To photograph the analyse the whitish glow discharge in air under reduced pressure.
9. To perform vibrational analysis of a band system of N2.
10. To perform vibrational analysis of band system of C2
11. To photograph and analyse the line spectrum of Calcium atom.
12. To record/analyse the fluorescence spectrum of a sample.
13. To record/analyse the Raman spectrum of a sample.
14. Study of Hyperfine structure of the green line of mercury.
15. To photograph the (O, O) band of CuH and to perform rotational analysis.
16. Flashing & quenching in Neon Gas.
17. E/m of electron.
18. Experiments on Prism/Grating Spectrometer.
19. Wavelength of laser light.
20. Faraday effect with laser.
21. Michelson interferometer.
22. Analysis of ESR Spectra of transition metals.
23. Analysis of H-atom spectra in minerals.
24. Measurements of dielectric constant of polymer sheet at low frequency.
25. E.S.R. of DPPH.
26. To measure the dielectric constant and polarisation of unknown liquid.
27. To measure the dielectric constant of unknown wood at microwave frequency
28. To measure the ultrasonic velocity in unknown liquid.

29. He-Ne Layer
30. To study polarisation of sodium light
31. To study polarisation of light using Babinet compensator

Methods of Theoretical Physics

1.Solving Laplace's equation
2. Bench problem (Pang)
3. The relaxation scheme for one dimension
4. Ground water dynamics
5. The time-dependent temperature field
6. Ising Model
7. 2-d Percolation
8. Classical Scattering

Ref: T. Pang

Nonlinear Dynamics

1.Bifurcation Diagram of logistic map.
2.Feigenbaum constant for period-doubling systems.
3.Study of Hopf Bifurcations.
4.Finding lyapunov exponent.
5.Fractal dimension of strange attractor.
6.Simulation of Lorenz attractor
7.Simulation of Rossler attractor
8.Multifractal spectrum of strange attractor.
9. Study of quantum chaos

Semester III Paper 12 (Foundation course F1.1) Fundamentals of Spectroscopy

Unit I

Atomic Spectra: The hydrogen atom and the three quantum numbers *n*, *l* and *ml*. – electronspin -Vector atom model-electron spin-Stern-Grelach experiment spectroscopic terms. Spin-orbit interaction, fine structure in sodium atom, selection rules.Lande g-factor, normal and anomalous Zeeman effects, Paschen–Back effect,Stark effect in one electron system. L S and j j coupling schemes (vector diagram) – examples

Unit II

Molecular Spectra:MicrowaveSpectra: Rotational spectra of rigid diatomic molecules - effect of isotopic substitution. Non–rigid rotor –
rotational spectra ofpolyatomic molecules

IR Spectra: Vibrating diatomic molecule as anharmonic oscillator, diatomic vibrating rotor – break down of Born-Oppenheimer approximation - vibrations of polyatomic molecules - overtone and combination frequencies - analysis by IR technique - Fourier transform IR spectroscopy.

Unit III

Raman Spectroscopy: Pure rotational Raman spectra - linear and symmetric top molecules - vibrational Raman spectra – Raman activity of vibrations - structure determination from Raman and IR spectroscopy.

Unit IV

Electronic Spectroscopy: Electronic spectra of diatomic molecules - progressions and sequences - intensity of spectral lines. Franck – Condon principle - dissociation energy Rotational fine structure of electronic-vibrational transition - Fortrat parabola – Pre dissociation energy-fluorescence and phosphorescence.

Reference Books:

1. Introduction of Atomic Spectra, H.E. White, McGraw Hill
2. Spectroscopy (Vol. 2 & 3), B.P. Straughan & S. Walker, Sciencepaperbacks 1976
3. Raman Spectroscopy, D.A. Long, McGraw Hill international, 1977
4. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill
5. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G.Herzberg, Van Nostard, London.
6. Elements of Spectroscopy, Gupta, Kumar & Sharma, PragathiPrakshan
7. The Infra Red Spectra of Complex Molecules, L.J. Bellamy,Chapman& Hall. Vol. 1 &2
8. Laser Spectroscopy techniques and applications, E.R. Menzel, CRCPress, India

Semester III   Paper 12 (Foundation course F1.2) Fundamentals of Nanoscience and Nanotechnology

Unit-I Basics of Nanoscience

Introduction to quantum physics, electron as waves, wave mechanics, Schrödinger equation and particle in a box, Heisenberg's uncertainty principle, exclusion principal, Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size
The p-n-junction and bipolar transistor, Metal semiconductor and metal insulator, semiconductor junction, field effect transistor.

Unit-II Properties of Nanomaterials

Mechanical, Thermal, Electrical, Optical, Magnetic and Structural.
Carbon nanostructures- Fabrication, structure, electrical properties and mechanical properties.

Unit-III Synthesis of Nonmaterial's

Physical methods**:** Bottom up-Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser pyrolysis, Sputter deposition, Electric arc deposition, Gas evaporation.
Chemical methods**:** Hydrothermal combustion, bath deposition with capping techniques and top down,Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Microemulsions, Sol-gel method, Combustion method, Wet chemical method

Unit-IV Bionanotechnology

Biological building blocks, nanostructure, protein nanoparticles, DNA double nanowire.
Bionanostructures- Micelles, vesicles, multilayer films, biological interactions, bilayers, bioelectronics and bioscensors.

Text and Reference Books:

1. Nanotechnology: Principles &Practicals. Sulbha K. Kulkarni, Capital Publishing Co.New Delhi.
2. Carbon nanotechnology..recent developments in Chemistry, Physics, materials science and device applications, -Elsevier Science
3.Nanostructures& Nanomaterials Synthesis, Properties & Applications. Guozhong Cao, Imperials College Press London
4. Physics, Chemistry and Application of Nanostructures, world scientific co.
5. Nanomaterials: Synthesis, Properties & Applications. Edited by A.S. Edelstein & R.C.Commorata. Institute of Physics Publishing, Bristol & Philadelphia.
6.Introduction to Nanotechnology. C.P. Poole Jr. and F. J.Owens, Wiley Student Edition.
7.Nano: The Essentials. T.Pradeep , McGraw Hill Education.
8. Handbook of Nanostructures: Materials and Nanotechnology. H. S. Nalwa Vol 1-5, Academic Press, Boston.
9.Nanoscience and Technology: Novel Structure and Phenomena. Ping and Sheng
10. Hand Book of Nanotechnology, Bhushan

Semester IV   Paper 13 (Core 11) Nuclear and Particle Physics

UNIT 1 ;

Basic nuclear properties; size, radii, shape, and charge distribution, spin, parity, mass, binding energy, semi-empirical mass formula, liquid drop model, nuclear stability, laws of radioactive decay. Nature of nuclear force, elements of deuteron problem, n-n scattering, charge independence and charge symmetry of nuclear forces.Electric and magnetic moments of nuclei.Evidence for nuclear shell structure, single particle shell model-its validity and limitations.

UNIT 2 :

Elementary properties of alpha-, beta-, and gamma-, decay of nuclei, their classification, characteristics and selection rules. Elementary theories of alpha-, beta-, and gamma-, decay. Nuclear reactions- conservation laws, mechanism, and cross section. Nuclear reaction mechanism, compound nucleus, direct reactions. Fission and fusion reactions, nuclear energy, elements of nuclear power.

UNIT 3 :

Interaction of charged particles and electromagnetic radiation with matter. Principles of nuclear radiation detectors: G-M counter, proportional counter, Na(Tl) scintillation detector, semiconductor detectors. Elementary principles of particle accelerators: linear accelerators, Van de Graaf, cyclotron, betatron, synchrocyclotron, ion beam accelerators.

UNIT 4 :

Classification of elementary particles, strong, weak and electromagnetic interaction.Gellmann-Nishijima formula Properties of hadrons, baryons, mesons, leptons, and quarks- their quantum numbers, charge, mass, spin, parity, iso-spin, strangeness etc. Symmetry and conservation laws.Elements of quark model and standard model.Higgs boson.

Text-books recommended:

1) Introductory Nuclear Physics,: Kenneth S Krane, Wiley, New York ,1988.
2) Nuclear and Particle Physics: Brian Martin.
3) Atomic and Nuclear Physics: S.N. Ghoshal.
4) Introduction to Particle Physics : D. Griffiths.
5) Introduction to Nuclear Physics: F. A. Enge, Addison Wesley (1975)
6) Introductory Nuclear Physics: Burcham

Semester IV Paper 14 (Core 12) Solid State Physics

Unit I: Band Theory: Bloch theorem, the Kronig- Penney model, construction of Brillouin zones, extended and reduced zone schemes, effective mass of an electron, tight binding approximation. Fermi surface.

Magnetic Properties:

Quantum theory of paramagnetism, magnetism of iron group and rare earth ions,.exchange interactions. Pauli paramagnetic susceptibility

Unit II

Lattice Dynamics: Energy of atomic motions, adiabatic principle, harmonic approximation, cyclic boundary condition.Lattice vibrations of linear monoatomic and diatomic chains.Dispersion relations, acoustic and optical phonons.

Theories of lattice specific heat, Dulong and Petit'slaw, Einstein and Debye models, T^3 law, Born procedure, anharmonicity and thermal expansion.

Unit III: Free Electron Theory: Electrons moving in one and three dimensional potential wells, quantum state and degeneracy, density of states, electrical and thermal conductivity of metals, relaxation time and mean free path, the electrical resistivity of metals, thermonic emission. Seebeck effect, thermoelectric power.

Semiconductors: Free carrier concentration in semiconductors, Fermi level and carrier concentration in semiconductors, effect of temperature on mobility, electrical conductivity of semiconductors, Hall effect in conductors and semiconductors.

Unit IV

Superconductivity, Type I and II super conductors, Meissner effect, isotope effect, London equation, coherence length, elements of B. C. S. theory, tunnelling DC and AC Josephson effect, Ginzberg-Landau Theory macroscopic quantum interference. Josephson junction.high temperature superconductor (elementary).

Text and Reference books:

1. C. Kittle: Introduction to Solid State Physics (2nd and 4th Edition).
2. A. J. Dekker : Solid State Physics.
3. Kubo and Nagamiya : Solid State Physics.
4. Feynman Lectures: Vol. III.
5. Board and Huano : Dynamical Theory of Crystal Lattice.
6. N. W. Ashcroft and D. Mermin: Solid State Physics.

Semester IV   Practical 7 for core papers

Practicals based on core 11 and core 12

1. Measurement of resistivity of a semiconductor by four probe method at two different temperatures and determination of band gap energy.
2. Measurement of Hall coefficient of given semiconductor: identification of type of semiconductor and estimation of charge carrier concentration.
3. Determination of Hall life of ‘In”.
4. Determination of range of Beta-rays from Ra and Cs.
5. G-M counter
6. Magnetoresistance by Hall effect
7. Determination of Dielectric constant
8. Random decay of nuclear disintegration using dice (or simulation)

In all 7 practicals, instructor can introduce new and relevant experiments which are not in the list.

Semester IV Paper 15 (Core Elective E2.1) Materials Science II

Unit –I

Mechanical response of Materials : Elasticity, model of elastic response, inelasticity, viscoelasticity, stress-strain curves, concept of various mechanical properties such as hardness, yield strength, toughness, ductility, yield toughness, ductility, brittleness, stiffness, young modulus, shear modulus, shear strength, Frenkel model, Peierls-Nabarro relation, Plastic deformation,

Corrosion and degradation of materials – electrochemical considerations – passivity forms of corrosion – corrosion inhibition.

Spintronics and Photonics: Spin glass, magnetic bubbles, domain walls, magnetic multilayers, magnenites, GMR and CMR, DMS materials. Photonic band gap materials.

Unit – II

Concept of Synthesis: Concept of equilibrium and nonequilibrium processing and their importance in materials science.

Synthesis of materials: Physical method – Bottom up: cluster beam evaporation, Ion beam deposition, Gas evaporation, Chemical method – Hydrothermal, combustion, bath deposition with capping techniques and top down: Ball milling. Solvated metal atom dispersion – thermal decomposition – reduction methods – colloidal and micellar approach.

Unit-III

Processing of materials: Metallic and non metallic, Ceramics and other materials. Only basic elements of powder technologies, compaction, sintering calcination, vitrification reactions, with different example, phenomenon of particle coalescence, porosity.Quenching : concept, glass formation

structural characterization:

Diffraction techniques: interpretation of x-ray powder diffraction patterns, Identification & quantitative estimation of unknown samples by X-ray powder diffraction technique Electron and neutron diffraction.

Unit –IV

Structural determination by fluorescent analysis. Theory and method of particle size analysis. Integral breadth method, Warren-Averbach's Fourier method, profile fitting method.

Microscopic techniques –TEM, SEM & STEM.AFM, EDX and XPS.

Text and Reference Books:

1. Basic Solid State Chemistry, 2nd Edition, Anthony R. West, John Wiley & Sons, 1996.

2. New Directions in Solid State Chemistry, C. N. R. Rao and J. Gopalkrishnan, Cambridge University Press, Cambridge, 1986.
3. Chemical approaches to the synthesis of inorganic materials, C. N. R. Rao Wiley Eastern Ltd.1994.
4. Materials Science and Engineering – An Introduction, W. D. Callister Jr. John Wiley & Sons,1991.
5. Materials Science, J. C. Anderson, K. D. Leaver, R. D. Rawlings and J. M. Alexander, 4^{th} Edition, Chapman & Hall (1994).
6. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press (1998).

Semester IV Paper 15 (Core Elective E2.2) X-ray II

Unit I
Space lattice and unit cell of a crystal, Choice of a unit cell, Crystal systems, Bravais lattices, Crystal faces and internal arrangement, Miller indices, Law of rational indices, Indices of a direction. Point groups, Space groups.
Perspective projections: Gnomonic projection, Stereographic projection, Orthographic projection.
Reciprocal lattice concept: Graphical construction, Relation to interplanar spacing, Interpretation of Bragg's law.

Unit II
Scattering of X-rays: Thomson scattering, Compton scattering, Wave mechanical treatment of scattering, Scattering by a pair of electrons, Theory of scattering by a helium atom, Scattering by many electrons, Experiments on scattering by monatomic and polyatomic gases, liquids and amorphous solids.

Unit III
Physical Basis of X-ray Crystallography: Atomic and crystal structure factors, Structure factor calculations, The integrated intensity of reflection. Different factors affecting the intensity of diffraction lines in a powder pattern.Dynamical theory X-ray diffraction.
The Fourier Transform, electron density projections in crystals, Application to X-ray diffraction.

Unit IV
Experimental Methods of Structure Analysis: Laue method, Debye-Scherrer method, rotation Oscillation method, Weisenberg camera, The sources of systematic errors and methods of attaining precision.
Principles of energy dispersive and time analysis diffractometry.
Methods of detecting and recording diffraction patterns.
Structures of metals and alloys. Phase transformations, Order-disorder phenomenon. Super lattice lines.Determination of grain size.
Other Diffraction Techniques: Electron and neutron diffraction tsechniques and their applications. Comparison with X-ray diffraction.

Text and Reference Books:

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment.
2. N. F.M. Henry, H. Lipson and W. A. Wooster: The interpretation of X-ray Diffraction Photographs.
3. K. Lonsdale: Crystals and X-rays.
4. B. D. Cullity: elements of X-ray Diffraction.
5. M. M. Woollfson: X-ray Crystallography.
6. M. J. Buerger: X-ray Crystallography.
7. Bacon: Neutron Physics.

Semester IV Paper 15 (Core Elective E2.3) NanoScience and Nanotechnology II

Unit – I:
Nanophotonics:
Fundamentals of photonics and photonic devices, Lasers, CFLs, LEDs, OLEDs, Wall paper lighting, Display devices, X-ray imaging nanophosphers, Photo therapy lamps and its applications, Nanomaterials for radiation, Dosimetery special for thermoluminescence. Optical stimulated luminescence, Luminescence solar concentration.

Unit – II:
Nanomagnetics:
Basics of Ferromagnetism, effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets, nanopore containment, giant and colossal magnetoresistance, applications in data storage, ferrofluids, Superparamagnetism, effect of grain size, magneto-transport, Magneto-electronics, magneto-optics, spintronics.

Unit – III:
Nanoelectronics:
Top down and bottom up approach, CMOS Scaling, Nanoscale MOSFETs, Limits to Scaling, System Integration, Interconnects;
NanoDevices: Nanowire Field Effect Transistors, FINFETs, Vertical MOSFETs, Other Nanowire Applications, Tunneling Devices, Single Electron Transistors, Carbon nanotube transistors, Memory Devices,

Unit – IV:
Nanocomposites:
Classification of nanocomposites, Metallic, ceramic and polymer nanocomposites, Tribology of polymeric nanocomposites, Nano ceramic for ultra high temperature MEMS, Optimizing nanofiller performance in polymers, Preparation techniques, Graphene/Fullerene/Carbon nanotube (CNT) polymer nanocomposites, One dimensional conducting polymer nanocomposites and their applications

Text and reference books:

1. H.S.Nalwa; Hand book of Nanostructure materials and nanotechnology; (Vol.1-5), Acad. Press, Boston, 2000
2. C.P.Poole Jr., F.J.Owens; Introduction to Nanotechnology, John Wiley and sons, 2003
3. C. Furetta; Hand book of thermoluminescence; World Scientific Publ.
4. S.W.S. McKEEVER; Thermoluminescence in solids; Cambridge Univ. Press.
5. Alex Ryer; Light measurement hand book; Int. light Publ.
6. M.J.Weber; Inorganic Phosphors; The CRC Press.

7. T.J.Deming; Nanotechnology; Springer Verrlag, Berlin, 1999
8. W.D.Kalister Jr., Materials Science and Engineering, 6th Eds, WSE Wiley, 2003
9. Gusev; Nanocrystalline Materials
10. C. Delerue, M.Lannoo; Nanostructures theory and Modelling
11. Fausto, Fiorillo ; Measurement and Characterization of Magnetic materials

12. Bhushan; Hand Book of Nanotechnology
13. Janos H., Fendler; Nanoparticles and Nanostructured Films
14. T.Pradip; Nano: The Essentials
15. Liu; Hand Book of Advanced Magnetic Materials (4 Vol.)
16. Lakhtakia; Nanometer Structure
17. Banwong, Anurag Mittal; Nano CMOS Circuit and Physical Design
18. G.W.Hanson: Fundamental of Nanoelectronics
19. Edward L. Wolf (2nd Ed.), *Nanophysics & Nanotechnology: An Introduction to Modern Concepts in Nanoscience*, WILEY-VCH, 2006
20. S. Sakka; Sol-gel science and technology processing, characterization and applications; Kluwer Acad. Publ.
21. Goser et al, "*Nanoelectronics&Nanosystems: From Transistor to Molecular & Quantum Devices"*
22. SupriyoDatta, "*From Atom to Transistor*"
23. John H. Davies, *The Physics of Low Dimensional Semiconductors: An Introduction",* Cambridge University Press, 1998.
24. Hari Singh Nalwa, "*Encyclopedia of Nanotechnology*"
25. A. A. Balandin and K. L. Wang, "*Handbook of Semiconductor Nanostructures &Nanodevices*"
26. Cao Guozhong, "*Nanostructures &Nanomaterials - Synthesis, Properties & Applications*

Semester IV Paper 15 (Core Elective E2.4) Atomic and Molecular Physics II

Unit I

Time dependence in quantum mechanics, Time dependent perturbation theory, rate expression for emission, perturbation theory, calculation of polarizability.Quantum mechanical expression for emission rate.
time correlation function and spectral Fourier transform pair, properties of time correlation functions and spectral time shape,
Fluctuation dissipation theorem rotational correlation function and pure rotational spectra,
Re-orientational spectroscopy of liquids.

Unit II

Saturation spectroscopy, Burning and detection of holes in Doppler broadened two level systems, Experimental methods of saturation spectroscopy in laser, Ramsey fringes, Saturation techniques for condensed matter application,
Laser optogalvanicspectroscopy.Two photon absorption spectroscopy, Selection rules, Expression for TPA cross section –photo acoustic spectroscopy, PAS in gaseous medium, Roseneweig and Greshow theory, Thermally thin, thick samples, Typical experimental set up, Application in Spectroscopy,

Unit III

Stimulated Raman scattering, Quantum mechanical treatment, Raman Oscillation Parametric instabilities, Electromagnetic theory of SRS.Vibronic interaction, Herzberg Teller theory,
Fluorescence spectroscopy, Kasha's rule, Quantum yield, Non-radioactive transitions, Jablonski diagram, Time resolved fluorescence and determination of excited state lifetime.Light detectors, Single photon counting technique, Phase sensitive detectors.

Unit IV

Matrix isolation spectroscopy, Fourier transforms spectroscopy, Laser cooling. Molecular symmetry and group theory, Matrix representation of symmetry elementsof a point group, Reducible and irreducible representations, and character tables specially for C_{2v} and C_3 point group molecules, Normal coordinates normal modes, Application of group theory to molecular vibrations.

Text Book and References:

1. Molecular Quantum Mechanics: P. W. Alkins and R. S., Fridman.
2. Quantum electron – A. Yariv.
3. Introduction to non-linear laser spectroscopy – M. D. Levenson.
4. Photoacoustics and its applications, Roseneweig.
5. J. M. Hollas, High resolution spectroscopy.
6. Cotton, Chemical Applications of Group Theory.
7. Herzberg, Molecular spectra and molecular structure II and III.
8. Demtroder, Laser spectroscopy and instrumentation.
9. King, Molecular spectroscopy.
10. Lakowicz, Principles of fluorescence spectroscopy.
11. Molecular Quantum Mechanics: P. W. Alkins and R. S., Fridman.

Semester IV Paper 15 (Core Elective E2.5) Applied Electronics II

Unit – I:

An Overview of Electronic Communication system ; block diagram of an digital electronic Communication system, Pulse modulation systems, sampling theorem, lowpass and band-pass signals,PAM channel bandwidth for a PAM signal, Natural sampling, flat top sampling, signal recovery throughholding, quantization of signals, quantization, differential PCM delta modulation, adoptive delta modulation CVSD. Digital modulation techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK. Mathematical representation of noise, sources of noise, frequency domain representation of noise, Noise in Pulse Code and Delta modulation system, PCM transmission, calculation of quantization of noise, out pit signal power effect of thermal noise, outr signal to noise ratio in PCM, DM, quantization noise in DM, out put signal power, DM oput-put, signal to quantization noise ratio, effect of thermal noise in delta modulation, output signal to noise ratio in DM.

Unit – II

Computer communication systems: Types of networks, design features of communication network,examples, TYMNET, ARPANET, ISDN, LAN.Mobile radio and satellite - time division multiplex access (TDMA) frequency division multiplex access(FDMA) ALOHA, Slotted ALOHA, Carrier sense multiple access (CSMA) Poisson distribution protocols.

Unit – III

Microprocessor and Micro-computers: Microprocessor and architecture, Pin out and pin functions of 8086/8088 Internal microprocessor architecture, bus buffering and latching ,Bus timings, ready and wait states, minimum mode versus and maximum mode. Real and protected mode of memory addressing, memory paging, addressing modes, data addressing modes, programme memory addressing mode, stack memory addressing modes, instruction sets, data movement instruction, arithmetic and logic instruction, programme control instruction, clock generator (8284A),

Unit –IV

Memory and I/O Interface : Memory devices, ROM,RAM.,DRAM, SRAM, Address decoding , 3 to 8 line decoder 74LS138, 8086, and 80386(16 bits) Memory interface, , Introduction to I/O interface , Interfacing using 8255, Introduction to PIT 8254, Basic Communication device(UART) pin diagram and functioning of 16550 Interrupts: Basic interrupt processing, Hardware interrupt, expanding the interrupt structure, 8259A PIC.

Text and Reference books.

1. Principles of communication systems :Taub and Schilling (ii Edn THM ,1994)
2. Principles of communication systems: Taub and Schilling GoutamSaha Third Edition
3. Communication systems : Simon Haykin (iii Edn John Wiley & Sons)
4. The intel microprocessors 8086/80188,80386,80486, Pentium and Pentium processor architecture, programming and interfacing : Barry B. Brey (PHI iv Edn, 1999)
5. Microprocessor and interfacing ,programming and hardware : Douglas V. Hall (ii Edn, Mc GrawHill International edn. 1992)
6. The 80x86 IBMPC compatible computer: Muhammad Ali Maxidi and J .G. Mazidi (ii Edn.Prentice –Hall International.)

Semester IV   Paper 15 (Core Elective E2.6) Methods of Theoretical Physics II

Many Body theory

Unit I: Second Quantization / Occupation Number Formalism

Wave functions for identical particles, symmetrized basis for Fermions and Bosons, one-particle and two-particle operators and their matrix elements in symmetrized basis; Number space representations of the basis, creation and annihilation operators, commutation relations; Representation of operators in terms of creation and annihilation operators; Equation of motion for operators in number space.

Unit II: Simple Applications

Electron gas: Hartree-Fock approximation, ground state energy and single particle energy in paramagnetic and ferromagnetic states, role of exchange term; Ground state of interacting bosons, Bose-Einstein condensate; Spectrum of elementary excitations, superfuidity.

Unit III: Green's Functions and Linear Response Theory

One-particle and two-particle Green's functions; Ground state energy and linear response in terms of Green's functions; Analytic properties of Green's functions; Equations of motion for Green's functions

Unit IV: Perturbation Theory

Interaction representation; Gell-Mann-Low theorem for ground state energy; Perturbation expansion for Green's functions, Wick's theorem; Diagrammatic representation, Dyson's equation, self energy; Polarization; Application to interacting Fermi gas: Dilute Fermi gas, Landau theory, Screening of coulomb interaction, random phase approximation for electron gas.

Text and Reference Books :

1. Stanley Raimes: Many-Electron Theory, *North Holland Publishing Co.*, (1972)

2. F. Mandl : Introduction to Quantum Field theory, *Interscience Publishers Inc.*, 1961

3. Abrikosov: Quantum Field Theoretical Methods in Statistical Physics

4. Fretter &Walecha: Quantum Theory of Many particle Systems

5. March, Young and Sampantha : The Many Body problems in Quantum Mechanics

6. Mattuch: Feynman Diagram Techniques.

Semester IV Paper 15 (Core Elective E2.7) Nonlinear Dynamics II

Unit I

Lorenz equations, chaos on a strange attractor, chaotic cryptography**,** Lorenzmap, properties of Lorenz system (Ch. 7 of ref. 1)

One dimensional Maps: Piecewise linear maps, logistic map, smooth 1-d maps, applications (ch. 2 of ref. 2)

Unit 2

Strange attractors: What is fractal, box counting dimension, generalized Baker map, dimension spectrum, introduction to multifractal. Singularity spectrum, partition function formalism (Ch. 3 and 9.1 9.2 of ref. 2, ch. 11, 12 of ref. 1)

Unit 3

Chaos in Hamiltonian systems:

Hamiltonian systems, perturbation of integrable systems, chaos and KAM tori describable by 2-d maps, higher dimensional systems, strongly chaotic systems, succession of increasingly random systems (Ch. 7 of ref. 2)

UNIT IV:

Control and synchronization of chaos: controlling chaos, controlling steadily running chaotic process, synchronization, generalized synchronization, phase synchronization

Elementary idea of quantum chaos: Energy and wavefunctions of chaotic bounded time independent systems, periodic systems, chaotic scattering (ref. 10 and 11 of 2)

Reference books:

1. S. W. Strogatz : Nonlinear Dynamics with Applications to Physics, Biology, Chemistry and Engineering. (Perseus)

2. Edward Ott : Chaos in Dynamical Systems (Cambridge University Press)

3. Quantum Chaos - An Introduction, H. J. Stöckmann, (Cambridge Univ. Press), 1999

4.. Classical and Quantum Dynamics, Dittrich and Reuter, 3rd Edition, (Springer Verlay), 2003.

Semester IV Paper 16 (Foundation course F2.1) Spectroscopic applications

Unit-I

Principle of spectroscopic instruments, UV-VIS visible: Absorption of light, radiation sources, sample holder, monochromator, radiation detectors, samples holder, monochromator, radiation detector, single and double beam experiment.

Infrared and Raman spectroscopy, predicting number of active modes of vibration, analysis of representative spectra of metal complexs with various functional groups at the coordination sites, organic and inorganic functional group identification through IR spectroscopy.

Unit-II

NMR phenomenon, spin ½ nuclei, (^{1}H, ^{13}C, ^{31}p and ^{1}9F), ^{1}H NMR, Zeeman splitting, effect of magnetic field strength on sensitivity and resolution, chemical shift , chemical and magnetic equivalence of spins, spin-spin coupling constant J.

Electronic spectroscopy, basic principle, electronic transitions in organic, inorganic and organometalic molecules and application to structure elucidation.

Unit-III

Electron paramagnetic resonance (EPR) spectroscopy of inorganic and organic compounds with unpaired electrons, determination of electronic structure, Zeeman splitting, g values hyoerfine and superhyperfime coupling constant.

Mossebauer spectroscopy-Mossebauer effect, recoilless emission and absorption, hyperfine interaction, chemical isomer shift, magnetic hyperfine and quadrupole interaction and interpretation of spectra.

Unit-IV

Mass spectroscopy, basic principles, ionization techniques, isotope abundance, molecular ion, high resolution MS, soft ionization methods, ESI-MS and MALDI-MS, illustrative example from macromolecules and supramolecules studies of inorganic/coordination and organometallic representative compounds.

Text books

1 Electronic paramagnetic transitions of metal ions, A Abragam, B Bleaney, Oxford University Press, 1970.
2. Physical methods for chemist, R S Drago, Saundevis 1992.
3.Fundamentals of molecular spectroscopy, C. N. Bawell and E.M. Mc cash, 4thed, MCGRAW-Hill, 1994.
4.NMR spectroscopy, H. Gunther, 2nd edition John Wileny and Sons, 1995.

Semester IV Paper 16 (Foundation course F2.2) Optics and Optical Instruments

Unit-1

General theory of image formation, Cardinal points of an optical system, thick lens and lens combination, telescopic combinations, telephoto lens and eyepieces, Abration in images; chromatic aberration, monochromatic aberration and their reductions, aspherical mirrors and correction plates, meniscus lens, entrance and exit pupil, need for multiple eyepiece, Ramsden and Huygens eyepiece, microscope and telescope, astronomical telescope.

Unit-2

Principal of superposition, coherence optical path retardation, fringes in thin film, localized fringes, two slit interference, Newton's rings and applications, Michelson interferometer and its applications,

Diffraction; Fresenel type- half period zone, rectilinear propogation, straight edge, Fraunhofer type-Diffraction at a slit, half period zone, circular aperature , plane transmission, reflection, blazed and concave grating, resolving power of grating, Raileigh criterion of resolution, resolving power of prism and grating.

Refraction- refraction in uniaxial crystal, double image prism, plane, circular and elliptical polarized light, Nicols prism, optical rotation in liquid crystals.

Unir-3

Optical instruments- magnifying glass, principal of pho camera, pinhole, lens and SLR camera, video camera, angular magnification, aperature, camera lucida, collimator and compound microscope, lens, periscope, binocular, field glass, jeweler's glass, projector, eyeglasses and its principal, prism spectroscope.

Unit-4

Holography: Importance of coherence, Principle of holography and characteristics, Recording and reconstruction, classification of hologram and application, non-destructive testing, optical fibre waveguides (step index, graded index, single mode), attenuation in fibre, couplers and connectors, LED,

X-ray –Principal and process of X-ray image (radiographs) production, factors affecting radiographs, Computed Tomography, principal and working of fluoroscopy, principal and working of CT-scanning, Ultrasound, working principal, imaging by us waves, Doppler ultrasound, magnetic resonance imaging, its working principal.

References;

1. Optics by Ajay Ghatak
2. Fundamental of optics by Jetkins and white
3.Optics and spectroscopy by R. Murugeshan, kiruthignsivaprakash.
4.Basic physics of X-ray imaging, Carl A Carlsson and Gudrun AlmCarlsson, 1996
5.Collaborative radiology by Chales De Kahn, 2013