M.Phil. in PHYSICS
(Specialisation: *Material Science & Technology*)

[FULL-TIME and PART-TIME]

(CBCS)

REGULATIONS, CURRICULUM AND SYLLABUS

(With effect from the Academic Year 2011 – 12)

PONDICHERRY ENGINEERING COLLEGE

Affiliated to Pondicherry University

Puducherry – 605 014

PONDICHERRY UNIVERSITY
PUDUCHERRY - 605 014

REGULATIONS FOR POST GRADUATE (M.Phil) PROGRAMME **(CBCS)**
(WITH EFFECT FROM JULY 2011)

1.0 ELIGIBILITY

1.1 M.Phil. in PHYSICS (Specialisation: Material Science & Technology)

Course duration:

a) **Full-time**: The course is for two semesters each of six months duration for Full-time students. Two compulsory papers will be taken in the first semester and one elective paper will be taken during the second semester. The project work will be taken during the second semester (6 months).

b) **Part-time**: The duration of course will be two years. The students will take the compulsory papers in the first semester and elective paper will be taken in the second semester. The project work will be taken during the second year (12 months).

Candidates for admission to the first semester/ first year (PT) of the two semesters/ two years (PT) M.Phil. Course should have passed ***Master's Degree in Science*** with Physics or Material Science & Technology as major subject ***with a minimum of 55% marks in the curriculum or equivalent CGPA.***

Note:

- There is no age limit for M.Phil. Course.
- There is no restriction for the students to apply for Part-time or Full-time.

2.0 ADMISSION

The admission policy for M.Phil. Programme shall be decided by the respective institutes offering M.Phil programme subject to conforming to the relevant regulations of the Pondicherry University.

3.0 STRUCTURE OF PG PROGRAMME

3.1 **GENERAL**

3.1.1. The M.Phil. Programme (full time) is of semester pattern with 16 weeks of instruction in a semester.

3.1.2 The Programme of instruction for each stream of specialisation will consist of:

(i) Core courses (Compulsory)
(ii) Electives
(iii) Seminar
(iv) Project work

3.1.3 The M.Phil (full time) Programme is of 2-semester duration and Two years for Part Time.

3.1.4. Credits will be assigned to the courses based on the following general pattern:

(i) One credit for each lecture period
(ii) One credit for each tutorial period
(iii) Two credits for seminar

(iv) Twelve credits for Thesis / Dissertation of Major Project work

One teaching period shall be of 60 minutes duration including 10 minutes for discussion and movement.

3.1.5 Regulations, curriculum and syllabus of the M.Phil in Physics Programme shall have the approval of Board of Studies and other Boards/ Committees/ Councils, prescribed by the Pondicherry University. The curriculum should be so drawn up that the minimum number of credits and other requirements for the successful completion of the Programme will be as given in Table – 1.

Table 1: Minimum credits and other requirements

Sl.No.	Description	Requirements for M.Phil in PHYSICS	
		Full-Time	Part-Time
1	Number of semesters	2	2 years
2	Min. number of credits of the programme	26	26
3	Max. Number of credits of the programme	28	28
4	Min. Cumulative Grade Point Average for pass	5	5
5	Min. successful credits needed for registering in the next semester	Sem. I: 5	Sem I: 5
6	Min. period of completion of programme (consecutive semesters)	2	2 years
7	Max. Period of completion of programme (consecutive semesters)	4	4 years
8	Number of core and Elective courses	3	3
9	Seminar	2	2
11	Project work (semesters)	1	2

3.1.6 A core course is a course that a student admitted to the M.Phil programme must successfully complete to receive the degree. A student shall register for all the core courses listed in the curriculum. The department concerned offers core courses in a particular specialisation.

3.1.7 Elective courses are required to be chosen from the courses offered by the department(s) in that particular semester from among the approved courses. A core course of one programme may be chosen as an elective by a student from other Department.

3.1.8 Each student is required to make a seminar presentation on any chosen topic connected with the field of specialization. Preparation and presentation of a seminar is intended to investigate an in-depth review of literature, prepare a critical review and develop confidence to present the material by the student. The seminar shall be evaluated by a Department Committee constituted for this purpose, based on a report submitted by the candidate and a viva-voce conducted at the end of the semester.

3.1.9 Project work is envisaged to train a student to analyze independently any problem posed to him/her. The work may be analytical, experimental, design or a combination of both.

The student can undertake the project work in the department concerned or in an industry/research laboratory approved by the Chairperson/Vice-Chairperson. The project report is expected to exhibit clarity of thought and expression. The Project will be evaluated by the guide chosen at the beginning of the course and the external examiner appointed by the Chairman, Post Graduate Studies, Pondicherry Engineering College, Puducherry. The projects will be evaluated continuously by the panel comprising of the Head of the Department, guide and two other members of the department for their internal assessment. Viva-Voce examination should be done by a committee comprising of HOD and the Guide concerned and another member of the department chosen by the Guide.

3.1.10 Directed study is a theory course required to be credited by each student under the close supervision of a faculty member of the department. The title of the course and syllabus are to be formulated by the designated faculty member and approved by the vice-chairperson, taking into account the broad area in which the student proposes to pursue his/her project work.

3.1.11 A student who has acquired the minimum number of total credits for the award of Degree will not be permitted to register for more courses for the purpose of improving his /her cumulative grade point average (see Table 1).

3.1.12 The medium of instruction, examination, seminar, and thesis / dissertation / project work will be in English.

3.2 GRADING

3.2.1 Based on the performance of each student in a semester, letter grades will be awarded to each course at the end of the semester. The letter grades, the corresponding grade point and the description will be as shown in Table – 2.

TABLE 2: Letter Grade and the Corresponding Grade Point

GRADE	POINTS	DESCRIPTION
S	10	EXCELLENT
A	9	VERY GOOD
B	8	GOOD
C	7	ABOVE AVERAGE
D	6	AVERAGE
E	5	SATISFACTORY
F	0	FAILURE
FA	-	FAILURE DUE TO LACK OF ATTENDANCE/ FAILURE BY ABSENCE

3.2.2 A student is deemed to have completed a course successfully and earned the appropriate credit if and only if, he /she receive a grade of E and above. The student should obtain 40% of marks in end-semester examination in a subject to earn a successful grade. A subject successfully completed cannot be repeated at any time.

3.2.3 The letter grades do not correspond to any fixed absolute mark. Each student is awarded a grade depending on his/her performance in relation to the performance of other students taking or has taken the course. For example, S does not mean he/ she has secured 100% or 95%, but, rather that he /she is in the top 5% of all the students who have taken / are taking the course, in the judgement of the teachers. Grades shall be awarded based on the absolute marks in a meeting of the PG Programme Committee to be held not later than 10 days after the last day of semester examination. Normally, not more than 5% of the students in any written course shall be awarded the grade S and not more than one–third awarded A grade. Average marks in the class shall normally be C grade excepting in the case of practical /project where it may be B grade.

4.0 REGISTRATION

4.1 Each student, on admission, shall be assigned a Faculty Advisor, who shall advise the student about the academic programme and counsel him/her on the choice of courses depending on his/her academic background and objective.

4.2 With the advice and consent of the Faculty Advisor, the student shall register for courses he/ she plans to take for the semester before the commencement of classes. No student shall be permitted to register for courses exceeding 30 contact hours per week nor shall any student be permitted to register for any course without satisfactorily completing the prerequisites for the course, except with the permission of the teacher concerned in the prescribed format.

4.3 If the student feels that he/she has registered for more courses than he/she can handle, he/she shall have the option of dropping one or more of the courses he/she has registered for, with the consent of his/her Faculty Advisor, before the end of 3rd week of the semester. However, a student to retain his/her status should register for a minimum of 10 credits per semester.

4.4 Students, other than newly admitted, shall register for the courses of their choice in the preceding semester by filling in the prescribed forms.

4.5 The college shall prescribe the maximum number of students in each course taking into account the physical facilities available.

4.6 The college shall make available to all students a bulletin, listing all the courses offered in every semester specifying the credits, the prerequisites, a brief description or list of topics the course intends to cover, the faculty offering the course, the time and place of the classes for the course.

4.7 In any department, preference shall be given to those students for whom the course is a core-course, if, the demand for registration is beyond the maximum permitted number of students.

5.0 EVALUATION

5.1 Evaluation of theory courses shall be based on 40% continuous internal assessment and 60% end-semester examination. In each course, there shall be a 3 hour end-semester examination.

5.2 The seminar will be evaluated internally for 100 marks. The allotment of marks for external valuation and internal valuation shall be as detailed below:

Seminar (Internal valuation only): **100** Marks

First review	30 marks
Second review	30 marks
Report and Viva voce	40 marks
Total	**100 marks**

Major Project work: 500 Marks

Internal valuation	
Guide	200 marks
Total	**200 marks**
External valuation	
Evaluation (External Examiner Only)	200 marks
Viva voce	100 marks
Total	**300 marks**

Viva-Voce examination should be done by a committee comprising of HOD and the Guide concerned and another member of the department chosen by the Guide.

5.3 The end-semester examination shall be conducted by the department for all the courses offered by the department. Each teacher shall, in the 4th week of the semester, submit to the Vice-Chairperson, a model question paper for the end-semester examination. The end-semester paper shall cover the entire syllabus.

5.4 The Chairperson shall invite 2 or 3 external experts for evaluating the end-semester examinations and grading. Each expert will be asked to set the question paper(s) for the course(s) he/she is competent to examine for the end-semester examination based on the model question paper as per prescribed pattern submitted by the teacher concerned. The teacher and the expert concerned shall evaluate the answer scripts together and award the marks to the student. If, for any reason, no external expert is available for any paper, then, the teacher concerned shall set the question paper(s) for the end-semester examination, and the teacher himself/herself shall evaluate the papers and award the marks.

5.5 After the evaluation of the end-semester examination papers, all the teachers who handled the courses and the external experts together shall meet with the PG Programme Committee and decide the cut-offs for grades in each of the courses and award the final grades to the students.

5.6 Continuous internal assessment mark of 40 for a theory course shall be based on two tests (15 marks each) and one assignment (10 marks).

5.7 Every student shall have the right to scrutinize his/her answer scripts, assignments etc. and seek clarifications from the teacher regarding his/her evaluation of the scripts immediately after or within 3 days of receiving the evaluated scripts.

5.8 The department shall send all records of evaluation, including internal assessment for safekeeping, to the college administration, as soon as all the formalities are completed.

5.9 At the end of the semester, each student shall be assigned a grade based on his/ her performance in each subject, in relation to the performance of other students.

5.10 A student securing F grade in a core course must repeat that course in order to obtain the Degree. A student securing F grade in an elective course may be permitted to choose another elective against the failed elective course, as the case may be, in consultation with the Faculty Adviser.

5.11 A student shall not be permitted to repeat any course(s) only for the purpose of improving the grade in a particular course or the cumulative grade point average (CGPA).

5.12 In exceptional cases, with the approval of the Chairperson, PG Programme committee, make–up examination(s) can be conducted to a student who misses end-semester examination(s) due to extreme medical emergency, certified by the college Medical Officer, or due to time-table clash in the end-semester examination between two courses he/she has registered for, in that semester.

5.13 All eligible students shall appear for end-semester examinations.

5.14 No student who has less than 75% attendance in any course will be permitted to attend the end-semester examinations. However, a student who has put in 60-75% attendance in any course and has absented on medical grounds will have to pay a condonation fee of Rs.200/- for each course and produce a medical certificate from a Government Medical Officer not below the rank of R.M.O. or officer of equal grade to become eligible to appear for the examinations. A student with less than 60% attendance shall be given the grade of FA. He/She shall have to repeat that course if it is a core course, when it is offered the next time.

6.0 SUMMER TERM COURSE

6.1 A summer term course (STC) may be offered by the department concerned on the recommendations of PG Programme Committee. A summer term course is open only to those students who had registered for the course earlier and failed. No student should register for more than two courses during a summer term. Those students who could not appear for examination due to lack of attendance will not be allowed to register for the same course offered in summer, unless, certified by the Vice-Chairperson concerned and the Principal.

6.2 Summer term course will be announced at the end of even semester. A student has to register within the stipulated time by paying the prescribed fees.

6.3 The number of contact hours per week for any summer term course will be twice that of a regular semester course. The assessment procedure in a summer term course will be similar to the procedure for a regular semester course.

6.4 Withdrawal from a summer term course is not permitted.

7.0 PG PROGRAMME COMMITTEE

7.1 Every M.Phil Programme shall be monitored by a committee constituted for this purpose by the college. Each committee shall consist of all teachers offering the courses for the programme and two student members or 10% of students enrolled whichever is less. The HOD or a senior faculty in the rank of a Professor shall be the Vice-Chairperson, nominated by the Head of the Institution. There shall be a common Chairperson in the Rank of Professor nominated by the Head of the Institution for all the P.G. programmes offered by the institute. There can be a common coordinator in the rank of Professor nominated by the Head of the Institution.

7.2 It shall be the duty and responsibility of the committee to review periodically the progress of the courses in the programme, discuss the problems concerning the curriculum and syllabi and conduct of classes. The committee may frame relevant rules for the conduct of evaluation.

7.3 The committee shall have the right to make suggestions to individual teachers on the assessment procedure to be followed for his/her course. It shall be open to the committee to bring to the notice of the Head of the Institution any difficulty encountered in the conduct of the classes or any other pertinent matter.

7.4 The committee shall meet at least twice a semester – first at the middle of the semester, and second at the end of the semester. In the second meeting, the committee excluding student members but with the external experts invited by the Chairperson PG Programme Committee, shall finalize the grades of the students.

8.0 MINIMUM REQUIREMENTS

8.1 To be eligible towards continuing the Programme, a student must have earned a certain number of successful credits at the end of each semester as given in Table – 1. If he /she fails to satisfy this criterion in any semester, he/she shall be placed on scholastic probation in the succeeding semester. If he/she fails to earn the number of credits by the end of that year (including courses taken in summer), then, he/she shall be asked to discontinue the Programme.

8.2 Students are expected to abide by all the rules of the college and maintain a decorous conduct. Any deviation will be referred to the Head of the Institution for suitable action.

8.3 No student who has any outstanding dues to the college, hostel, library or laboratory or against whom any disciplinary action is contemplated/ pending will be eligible to receive his/her degree.

9.0 DECLARATION OF RESULTS, RANK AND ISSUE OF GRADE CARD

9.1 The PG Programme (CBCS) office shall display the grades as soon as possible after the finalization of the grades. The student shall have the right, for a look at the evaluated examination scripts and represent to the PG. Programme Committee for review if he/she feels aggrieved by the evaluation within a week from the commencement of succeeding semester classes.

9.2 The College shall issue at the beginning of each semester a grade card to the student, containing the grades obtained by the student in the previous semester (s) and his/her Grade Point Average (GPA) and his/her Cumulative Grade Point Average (CGPA).

9.3 The grade card shall list:

a) Title of the course(s) taken by the student.
b) Credits associated with each course.
c) Grade secured by the student.
d) Total credits earned by the student in that semester.
e) GPA of the student.
f) Total credits earned by the student till that semester and
g) CGPA of the student.

9.4 The GPA shall be calculated as the weighted average of the Grade Points weighted by the credit of the course as follows:

The product of the credit assigned to each course and the grade point associated with the grade obtained in the course is totaled over all the courses and the total is divided by the sum of credits of all the courses and rounded off to two decimal places.

For example, a student securing grade A in a 4 credit course, grade B in a 2 credit course, grade S in a 3 credit course and grade F in a 3 credit course, will have a GPA as:

(9 x 4 + 8 x 2 + 10 x 3 + 0 x 3)/ (4+2+3+3) =82 /12=6.83/10.0

The sum will cover all the courses the student has taken in that semester, including those in which he/she has secured grade F. Grades FA are to be excluded for calculating GPA and CGPA.

9.5 For computing CGPA, the procedure described in 9.4 is followed, except, that the sum is taken over all the courses the student has studied in all the semesters till then. If a student has repeated any course, the grade secured by him/her in the successful attempt only will be taken into account for calculating CGPA.

9.6 To convert CGPA into percentage marks, the following formula shall be used:

$$\% \text{ Mark} = (\text{CGPA} - 0.5) \times 10$$

9.7 A candidate who satisfies the course requirements for all semesters and passes all the examinations prescribed for all the Two semesters within a maximum period of 4 semesters reckoned from the commencement of the first semester to which the candidate was admitted shall be declared to have qualified for the award of degree.

9.8 A candidate who qualifies for the award of the degree shall be declared to have passed the examination in **FIRST CLASS** with **DISTINCTION** upon fulfilling the following requirements:

(i) Should have passed all the subjects pertaining to semesters 1 to 2 in his/her first appearance in 2 consecutive semesters starting from first semester to which the candidate was admitted.

(ii) Should not have been prevented from writing examinations due to lack of attendance

(iii) Should have secured a CGPA of 8.50 and above for the semesters 1 to 2.

9.9 A candidate who qualifies for the award of the degree by passing all the subjects relating to semesters 1 to 2 within a maximum period of 4 consecutive semesters after his/her commencement of study in the first semester and in addition secures CGPA not less than 6.5 shall be declared to have passed the examination in **FIRST CLASS**.

9.10 All other candidates who qualify for the award of degree shall be declared to have passed the examination in **SECOND CLASS**.

9.11 A student with CGPA less than 5.0 is not eligible for the award of degree.

9.12 For the award of University rank and gold medal, the CGPA secured from 1st to 4th semester should be considered and it is mandatory that the candidate should have passed all the subjects from 1st to 4th semester in the first appearance and he/she should not have been prevented from writing the examination due to lack of attendance and should not have withdrawn from writing the end-semester examinations.

10.0 EQUIVALENCE

The Curriculum and Syllabus of M.Phil in Physics (Specialisation: Material Science & Technology) is Equivalent to One Year Degree Course in M.Phil (Physics – Full Time) offered by other recognized Indian Universities.

11.0 PROVISION FOR WITHDRAWAL

A candidate may, for valid reasons, and on the recommendation of the vice-chairperson and chairperson be granted permission by the Head of the Institution to withdraw from writing the entire semester examination as one unit. The withdrawal application shall be valid only if it is made earlier than the commencement of the last theory examination pertaining to that semester. Withdrawal shall be permitted only once during the entire programme. Other conditions being satisfactory, candidates who withdraw are also eligible to be awarded DISTINCTION whereas they are not eligible to be awarded a rank/ gold medal.

12.0 TEMPORARY DISCONTINUATION FROM THE PROGRAMME

If a candidate wishes to temporarily discontinue the programme for valid reasons, he/she shall apply to the Chairperson, PG Programme committee, through the Head of the department in advance and secure a written permission to that effect. A candidate after temporary discontinuance may rejoin the programme only at the commencement of the semester, at which he/she discontinued, provided he/she pays the prescribed fees. The total period of completion of the programme reckoned from the commencement of the first semester to which the candidate was admitted should not in any case exceed 10 consecutive semesters including the period of discontinuance.

13.0 POWER TO MODIFY

12.1 Notwithstanding anything contained in the foregoing, the Pondicherry University shall have the power to issue directions/ orders to remove any difficulty.

12.2 Nothing in the foregoing may be construed as limiting the power of the Pondicherry University to amend, modify or repeal any or all of the above.

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M.Phil in PHYSICS

CURRICULUM AND SCHEME OF EXAMINATION

(Total number of credits required for the completion of the Programme: 26)

SEMESTER – I

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	PH MP C01	Research Methodology	3	1	0	4	40	60	100
2.	PH MP C02	Advanced Material Science	3	1	0	4	40	60	100
3.	PH MP C03	Seminar I	2	0	0	2	100	-	100
						10	**180**	**120**	**300**

SEMESTER – II

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	-	Elective	3	1	0	4	40	60	100
2.	PH MP C04	Seminar II	2	0	0	2	100	-	100
2.	PH MP C05	Major Project*	-	-	12	12	300	200	500
						18	**440**	**260**	**700**

*The project work will be allotted during the second year for part time candidates.

CORE COURSES:

CODE	SUBJECT	Credits	Hours	Marks
PH MP C01	Research Methodology	4	4	100
PH MP C02	Advanced Material Science	4	4	100
PH MP C03	Seminar I	2	2	100
PH MP C04	Seminar II	2	2	100
PH MP C05	Major Project (Dissertation & Viva)	12	12	500

ELECTIVE COURSES:

[Credits = 4 Hours = 4 Marks = 100]

PH MP E01	Advanced Condensed Matter Physics
PH MP E02	Characterisation for Advanced Devices
PH MP E03	High Temperature Superconductors
PH MP E04	Laser Theory and Applications
PH MP E05	Luminescence and Applications
PH MP E06	Nanotechnology and Nanoscale Processing
PH MP E07	Phase Transition and High Pressure Physics
PH MP E08	Semiconducting Materials and Optoelectronics

PH MP C01 – Research Methodology

Unit I

Research Methodology: Meaning of research – Objectives & Motivation of Research – Types of research – Research approaches – Significance of Research – Research Process – Criteria of Good research – Selection of research Problem.

Unit II

Research Design: Meaning of Research Design – Need for Research Design – Features of Good Design – Concepts – Different Research Design – Basic Principles of Experimental Designs

Unit III

Computer's role in Research: Computer and computer Technology – Computer System – Important Characteristics – Binary Number system – Computer applications – Computers and Researcher

Unit IV

Numerical methods: Numerical integration - Simpson's rule - Trapezoidal rule - Numerical Differentiation - Numerical solution of ordinary differential equations - Runge Kutta method –Taylor series method - Solution of partial differential equations - Elliptic equation - Parabolic equation - Hyperbolic equation-Difference equations.

Unit V

Preparation of Technical papers and thesis writing - art of writing of scientific article - writing a thesis - Presentation of data – Symbols - the observations - tables and figures – equations - the style - sentence length - page and chapter format - referencing.

Books

1. Research Methodology – C R Kothari, New age International, New Delhi - 2004
2. Research Ed C.Hawkins & M Sorgi, Norosa Publishing House, New Delhi - 2000
3. Introduction to Numeric Methods by M.K. Venkataraman.
4. Numerical Recipes in C (The art of Scientific computing) by William. H. Press et al., Cambridge University Press, India.(1996)
5. Numeric Methods by E. Balagurusamy, Tata Mc Graw Hill.
6. A hand Book of Methodology of Research, Rajammal et al., Sri Ramakrishna Mission Vidyalaya Press, Coimbatore.

PH MP C02 – Advanced Material Science

UNIT- I

Elements of X-ray diffraction - Powder method - Choice of radiation - Background radiation - Crystal monochromators - Measurement of particle size by XRD. Measurements of residual stress - General principles of phase diagram determination - Order-disorder transformations.

UNIT-II

Review of symmetry properties of solids - Electronic band structure of solids - Density of states - Tight binding approximation - Elements of LMTO method – Experimental methods of determination of electronic structure of solids.

UNIT-III

Principles of magnetic measurements - Basic ideas of measuring M, chi and Tc - Magneto-Thermal effect - Magneto-resistance - magneto-optical phenomena - Magneto acoustic effect - engineering applications of soft and hard magnetic materials - magneto optic recording - Bubble domain device - Importance of magnetic anisotropy.

UNIT-IV

Hall Effect in semiconductors - Cyclotron resonance - de Hass oscillations- Semiconductor epitaxy - Materials for optical fiber communications - Fabrication of optical fibers - elements of non-linear optical materials.

UNIT-V

Principles of formation of solid solutions - Vegard's law - Hume-Rothery rules – Electrical conductivity in metals - Matthiesen's rule – Electrical resistivity of concentrated Alloys - Kondo effect - Engineering application of superconductors.

References

1. Neil W Ashcroft and N David mermin, Solid State Physics, Holt Saunders International Edn, 1976.
2. Soshin Chikazumi, Physics of Ferromagnetism, Clarendon Press, Oxford, 2nd edition, 1997.
3. BD Cullity, Introduction to Magnetic Materials, Addison-Wesley, 1972.
4. BD Cullity, Elements of X-ray diffraction, Addison-Wesley, 2nd edition, 1978.
5. JS Dugdale, The Electrical Properties of Metals and Alloys, Edward Arnoid, 1977
6. Harald Ibach and Hans Luth, solid state physics: An Introduction to principles of materials Science, Springer- Verlag, Berlin, 2nd edition 1996.
7. David Jiles, Introduction to Magnetism and Magnetic Materials, Chapman and Hall, 1991.
8. Gerd Kesier, Optical Fiber Communications, McGrew Hill, 2000.
9. Paul L Rossiter, The Electrical Resistivity of Metals and Alloys, Cambridge university Press, 1991.
10. HL Skiver, The LMTO Method, Springer- Verlag, Berlin, 1984.

PH MP E01 – Advanced Condensed Matter Physics

UNIT- I

Band Theory

Free electron Theory – Bloch's theorem – Band structure calculation – APW method – Linear methods – different exchange correlation schemes – total energy calculations – structural stability – EOS – Experimental study of band structures.

UNIT-II

Lattice Dynamics

Born - Oppenheimer approximation – Harmonic approximation – Brillouin zones – phonon dispersion in solids – phonon softening

UNIT-III

Transport Properties

Electrical conductivity – thermals conductivity – thermo electric power – Hall effect – Magneto resistance effect – normal and umklapp process.

UNIT-IV

Optical Properties

Index of refraction – damping constant – characteristic penetration depth - absorbance – reflectivity and transmissivity – point defect – colour centers – luminescence – excitons – polaron – interband – intra band transitions – dispersion relation

UNIT-V

Atomic Molecular Structure

Central field approximation – Thomas Fermi model and its application – Hartree and Hartree Fock equations – Hydrogen molecule – Heitler London model – LCAO – hybridization

References

1. Neil W Ashcroft and N David Mermin, Solid State Physics, Holt Saunders International Edn, 2000.
2. Harald Ibach and Hans Luth, solid state physics: An Introduction to principles of materials Science, Springer- Verlag, Berlin, 2nd edition 1996.
3. GC Fletcher, Electron theory of solids, North Holland, 1980
4. HL Skiver, The LMTO Method, Springer- Verlag, Berlin, 1984
5. R E Hummel. Electronic properties of materials, Narosa 1993
6. S Raimes, The wave mechanics of electron in metals, North Holland, 1967

PH MP E02 – Characterisation for Advanced Devices

UNIT I

X-ray diffraction

X-ray diffraction – single crystal and powder diffraction methods – Debye Scherrer method, seeman – Bohlin, Guiner cameras- interpretation of diffraction patterns - indexing, systematic absences - space group determination - use of powder diffraction files - identification of compounds - particles size determination - X-ray photoelectron microscopy (XPS).

UNIT II

Spectroscopic methods

Introduction – UV Visible molecular absorption spectrometer – Beer's Law – Qualitative and quantitative analysis by absorption measurements – band gap determination for semiconductors – Photo acoustic spectroscopy - instrumentation – application – Introduction to IR spectroscopy – FT spectroscopy – instrumentation – advantages of FTIR spectrometer – applications - Introduction to Raman Spectroscopy and its applications

UNIT III

Optical methods and Electron Microscopy

Photoluminescence – light – matter interaction – fundamental transitions – excitons – instrumentation – electro luminescence – instrumentation – thermo luminescence – cathodoluminescence – application – applications – introduction – electron microscopes – principles of SEM, TEM, EDAX, AFM, EPMA.

UNIT IV

Chemical Analysis of Surfaces

Surface spectroscopy – Ion scattering spectroscopy - Ion scattering spectrometer – secondary ion mass spectrometry (SIMS) – instrumentation – Auger emission spectroscopy – Instrumentation – ESCA – instrumentation – LEED and reflection high energy electron diffraction (RHEED)

UNIT V

Electrical methods and dielectric measurements

Nanoscale I-V / C-V characteristics – quantum hall and fractional quantum hall effects – resistivity – two probe and four probe methods – vander paur method – Schottky barrier capacitance – impurity concentration – electrochemical CV profiling – limitations – Dielectric, Electrical conduction in crystal dielectrics – suffface conduction – dielectric loss – LCR meters

Reference Books:

1. Introduction to Nanotechnology, Charles P Poole Jr and Frank J.Owens, Wiley-Interscience, 2003.
2. A basic course in crystallography, Jsk Tareen & TRN kutty, University press 2001
3. Instrumental methods of Chemical Analysis, H Gaur, Pragathi Prakasan, 1st Edn 2001
4. Instrumental methods of Analysis, Willard Merritt, CBS publishers, 2005
5. Electron microscopy and microanalysis of crystalline materials J A Belk, Applied Science Publishers, 1979
6. Physics of dielectric materials B Tareev, Mir Publiactions, 1979

PH MP E03 – High Temperature Superconductors

Unit I

Review of basics of Superconductivity – Critical Temperature – Effects of Magnetic field – Critical field – Type I and Type –II Superconductors – Critical Current – Magnetic Properties – Meissner effect – Lattice specific heat – energy gap – Isotope effects – Thermodynamics of Superconductivity – Two fluid model – Theory of Superconductivity – BCS theory – Superconducting ground state – Electrodynamics of Superconductors – London Equation – Ginsburg-Landau Theory – Flux Quantisation – Super Current Tunneling – Josephson effect – SQUIDS.

Unit II

Copperless Oxide Superconductors – Preparation and phase diagram of HTSC families – Lanthanum Strontium Cuprate ($La_{2+x}(Ba,Sr)_xCuO_{4-\delta}$) – Yttrium Barium Copper oxide ($YBa_2Cu_3O_{7-\delta}$) – Bismuth Strontium Calcium Copper oxide ($Bi_2Sr_2Ca_{n-1}Cu_{2n+4+\delta}$) – Thallium Barium Calcium Copper oxide ($Tl_mBa_2Ca_{n-1}Cu_nO_{2+m+2n}$(m=1,2, n=1,2,3) – Mercury Barium Calcium Copper oxide ($HgBa_2Ca_{n-1}Cu_nO_{2+m+2n}$) - and Lead Cuprate superconductors($Pb_2Sr_2LnCu_3O_8$) and electron doped superconductors.

Unit III

Crystallographic and structural properties of high temperature superconductors - Dependence of T_c on crystal structure –number of CuO layers - Mixed Valency - Charge Balance – dopant concentration - ionic radii – Oxygen non-stiochiometry - Effects of pressure. Tc suppression mechanism - Hole filling Theory – Redox mechanism- Effect of magnetic impurities – Abrikosov-Gorkhov theory - common features of high temperature superconductors.

Unit IV

Characterization of high temperature Superconducting materials –XRD - electrical Resistivity – linear four probe – Square array (Van der Pauw technique) – magnetic susceptibility – FTIR technique – band gap energy measurement – FT Raman measurements – Phonon Soft modes – Neutron scattering. Theory of high temperature Superconductors – Failure of BCS theory – Anderson's Resonating Valence Bond (RVB) theory – Magnon and plasmon pairing – Polaron mechanism – Applications of high temperature Superconductors.

Unit V

Magneto résistance in metals – Expression for magneto resistance using Lorentz force for single charge carrier – Positive and Negative magetoresistance – Magneto resistance in ceramic compounds – Giant Magneto resistance (GMR)/Colossal Magneto resistance (CMR) – Magneto résistance in single perovskite (ABO_3) – Double perovskite – pyrochlores – Preparation and structural characterization – Heisenberg's exchange interaction in magnetic materials – Superexchange interaction – Double exchange mechanism in CMR/GMR compounds - T_c and Curie temperature dependeance – transition from paramagnetic to semiconducting to Ferromagnetic metal and Ferromagnetic metal to antiferromagnetic insulator – charge ordering – Variation of T_c as function of dopant concentraction, ionic radii and crystal structure. Measurement of MR ratio – applications – optoelectronics, magnetic field sensors, spin transistor.

References:

1. Elementary Solid state Physics – Principles and applications, M. Ali omar, Addison Wesly, 2000.
2. Physical Properties of high temperature Superconductors, Ed. Donald M. Ginsberg, World Scientific, Singapore, 1989.
3. Space groups for Solid State Scientists, G. Burns and A. M. Glazer, Academic Press Inc, 1990.
4. Crystal Chemistry of high T_c temperature Superconducting Oxides, B. Raveau, C. Michel, M. Hervieu and D. Groult, Springer verlag, 1991.
5. Thallium based high temperature Superconductors, Ed. Allen M. Hermann and J. V. Yakmi, Marcel Dekker Inc, 1994.
6. Chemistry of high temperature Superconductors Ed. C. N. R. Rao, World Scientific. 1991.
7. Physics of magnetic semiconductors, E. L. Ngaev, MIR Publishers, Moscow, 1983.

PH MP E04 – Laser Theory and Applications

UNIT I

PRINCIPLES OF LASERS

Einstein coefficients, ratio of rates of stimulated and spontaneous emission – Threshold condition for laser action – Small signal gains of a laser – Population inversion in three level and four level systems

UNIT II

OPTICAL RESONATORS

Resonant cavities, resonator modes, spot size – Types of resonators, geometries, alignment characteristics, stability criterion, quality factor of an optical resonator – Q-switching and Mode locking concepts and techniques.

UNIT III

LASER SYSTEMS

Gas lasers: He-Ne laser, Carbon dioxide gas laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, Semiconductor Laser– Liquid Lasers: Dye lasers

UNIT IV

MATERIALS PROCESSING

Gaussian beam characteristics - Spot size - Power density - Welding - Fusion depth and welding geometry - Welding speeds - Advantages and uses of laser welding - Drilling hole geometry - Advantages and uses of laser drilling - Micromachining resistor trimming - Capacitor adjustment and fabrication, Scribing - Controlled fracturing.

UNIT V

APPLICATIONS

Laser ranging and tracking - Laser Doppler velocimetry - Ring laser and rotation sensing - Pollution monitoring, Alignment monitoring - Holography and speckle in displacement and deformation measurements - Biological and medical applications - Laser for communication with fiber optics as channel.

References:

1. Oshea, W.R. Callen and N.T. Rhodes, 'An Introduction to Lasers and their Applications', Addison Wesley, 1969.
2. J. Verdeyen, 'Laser Electronics', Second Edition, Prentice Hall, 1990.
3. S.S. Charchan, 'Laser in Industry', Van Nostrand Reinhold Co., 1975.
4. Goldman and Rockwell, 'Lasers in Medicine', Gordon and Breach, New York, 1985.
5. B.B. Laud, 'Laser and Non-Linear Optics', Second Edition, New Age International (p) Limited publishers, 1996.

PH MP E05 – Luminescence and Applications

Unit I:

Optical properties of materials.

Electromagnetic waves in Non conducting media – Optical Constants – Absorption coefficient and Beer's law of absorption – Absorption in semiconductors and insulators – Fundamental absorption – Excitons – Photon–assisted transition - Free carrier absorption in semiconductor (without derivation). Absorption measurements – UV - VIS – IR double beam spectrophotometer – Absorption in KCl: Tl.

Unit II:

Luminescence:

Introduction – Excitation and Emission – Configuration Coordinate diagram – Franck Condon Principle – Radiative Transitions – Radiation less transitions – Fluorescence and Phosphorescence – Decay mechanisms of phosphorescence – Photon emission processes Semiconductors, ZnS and alkali halides phosphors – Photoluminescence – Electro luminescence – Cathodoluminescence.

Unit III:

Colour centers:

Point defects – Schottky and Frenkel defects in alkali halides – Methods of Colouration – Various types of colour centers – electron trapped and hole trapped centers – Aggregates and impurity perturbed centers – General characteristics of F, V_k and H centers – Their characteristics by different experimental methods – Mechanism of production of colour centers by additive colouration and radiolysis methods.

Unit IV

Thermally Stimulated Luminescence (TSL)

Introduction – Mechanism of TSL – Theory of TSL - I order and II order kinetics – Experimental arrangements for TSL – Photomultiplier tube – Construction and working – Initial rise method, Half-width method, Variable heating rates method, Isothermal decay methods – Analysis of the total glow peak – TSL emission spectra – TSL glow and emission in KCl:Tl – Photo Stimulated Luminescence (PSL).

Unit V:

Materials and applications:

Applications of TSL with special reference to TSL Dosimetry – Preparation methods for different TLD materials – Comparative study of TLD materials – Application of PSL X-ray image Phosphor, X-ray image intensifiers – Lamp phosphors – LED – Display devices – white LED

Reference:

1. Solid State Physics, A. J. Dekker, Macmillan (1986).
2. Introduction to solid-state physics and its applications, Elliot & Gibson, ELBS (1982).
3. Colour centers and imperfections in insulators and semiconductors, P. D. Townsend and J. C. Kelley, Sussex University Press, (1973).
4. Techniques of Radiation dosimetry, K. Mahesh & D. R. Vij, John Wiley (1988).
5. Thermo luminescence of Solids, S.W.S. Me Keever., Cambridge University Press, (1985).
6. Diagnostic X-ray Imaging using photostimulable luminescence phosphor: An emerging alternative Photographic film, A. R. Lakshmanan & K. G. Rajan, Radiation protection dosimetry, Vol:55, No. 4, pp – 247 -255 (1994).
7. Fluorescent Lamp phosphors, Alok M. Srivastava & Timothy J. Sommerer., The Electrochemical Society Interface, Summer (1998).
8. K. H. Butler, Fluorescent Lamp phosphors, The Pennsylvania State University Press (1980).

PH MP E06 – Nanotechnology and Nanoscale Processing

Unit I

Introduction and Properties of Individual Nanoparticles:

Introduction – nanomaterials - metal nanoclusters – magic numbers – theoretical modeling – geometric and electronic structure – magnetic clusters – semiconducting Nanoparticles - optical properties – photofragmentation - columbic explosion – rare gas and molecular clusters – role of surface in nanotechnology devices – surface reconstruction – dangling bonds and surface states.

Unit II

Carbon nanostructures and Nanostructured ferromagnetism:

Introduction – carbon molecules – carbon clusters – discovery – structure – carbon nanotubes – properties and application.

Nanostructured ferromagnetism – dynamics - nanocarbon ferromagnets – Giant and colossal magnetoristance – Ferro fluids.

Unit III

Bulk nanostructured materials:

Solid disordered nanostructures – synthesis – nanostructuered multilayres - mechanical and electrical properties – metal nanoclusters composite glasses – nanostructured crystals – natural nanocrystals – crystals of metal Nanoparticles – nanoparticles lattices in colloidal suspensions – Photonic crystals.

Unit IV

Processing and fabrication I

Si processing methods – etching, Oxidation, gettering, doping, epitaxy, sputtering, chemical vapour Deposition (CVD), Plasma enhanced CVD, relative ion etching (RIE), Moore's law, Top down approach to nanolithography, photolithography, sol gel method, Plasma arcing, ball milling method, merits and demerits.

Unit V

Processing and fabricatin II

Chemical methods - thermolysis - Pulsed laser methods - processing of III - V semiconductors including nitrides – molecular beam epitaxy (MBE) – chemical beam epitaxy (CBE) - metal organic CVD (MOCVD), quantum wells, Si-Ge, SiC, Diamond: synthesis, defects and properties on the Nanoscale.

Reference Books:

1. Nanotechnology, Mick Wilson et al, Overseas Press, 2005.
2. Introduction to Nanotechnology, Charles P Poole Jr and Frank J.Owens, Wiley-Interscience, 2003.
3. Handbook of Nanoscience, Engineering and Technology. Ed.by William A. Goddard III,Donald W.Brenner, Sergey Edward Lyshevsky, and Gerald J.Iafrate.

PH MP E07 – Phase Transition and High Pressure Physics

Unit I

Electronic band structure of solids:

One Electron Approximation – Energy Band Problem – Nearly Free Electron Approximation – Tight Binding Approximation – Survey of Linear Band structure Methods – Motion of Electron in Bands and Effective Mass – Cohesive Properties – Electron Pressure Relation – Quantum Oscillations and Topology of Fermi Surfaces.

Unit II

Solid State phase transformation:

Phase Change – Types of Phase Transformation – Thermodynamics of Transformations – Classification and Relations at Phase transition – First and Second Order Transformations – Hysteresis in Phased Transformations – Irreversible Phase Transformations – Structural Basis for Classification and Prediction of Phase transitions.

Unit III

High Pressure Devices for Various Applications

X-ray Diffraction, Neutron Diffraction – Optical Studies – Electrical Studies – Magnetic Studies – High and Low Temperature Applications – Ultra High Pressure anvil devices

Unit IV

Dynamic Pressures:

Equation of State – Shock Waves – generation – measurements - Effect of shock on metals – Application of Shock Waves – Superhard Materials - Diamond

Unit V

Physical and Chemical Properties under high pressure:

PVT Relation in Fluids – Properties of Gases Under Pressure – Thermo emf – Thermal and Electrical Conductivity – Electronic and Structural Transitions in Metals – Electronic Structure of Metals and Semiconductors – Magnetic Properties.

Text Books:

1. Solid State Physics, Harald Ibach and Hnas Luth, Narosa Pup. House New Delhi, 1992.
2. Solid State Physics, Achcroft and Mermin, WB Saunders Company, Philadelphia, 2000.
3. The LMTO Method, Hans L. Skriver, Springer Verlak, Berlin, 1984.
4. Solid State Phase Transitions, V. Raghavan, Prentice Hall of India, 1992 and Phase Transitions in Solids by K J Rao and C N R Rao.
5. High Pressure Science and Technology, Vol. I & II, B. Vodar and Ph. Merteam, Pregamom Press, Oxford, 1980.
6. Experimental Techniques in Condensed matter Physics at Low Temperature, Robert C Richardson and Eric N Smith, Addison Wesley Pub. Company, California, 1988.
7. Mechanical Behaviour of Materials under Pressure, HLD Pugh, Elsevier Pub. Co. Ltd, New York 1970.
8. Solid State Physics, Vol. 13, 17 and 19, Frederick and Turnbull, Academic Press, New York, 1962.

PH MP E08 – Semiconducting Materials and Optoelectronics

UNIT I

Semi conducting materials

Introduction- band structure of semiconductors – element and compound semiconductors – intrinsic and extrinsic semiconductors – electron density – hole density – electrical conductivity - hall effect.

UNIT II

Quantum wells, wires, dots, self assembly and catalysis

Quantum wells, wires, dots - introduction – preparation of quantum nanostructures – size effects - excitons – single electron tunneling – applications.

Self assembly – Process - Semiconductors islands - monolayers – catalysis – nature – surface area of Nanoparticles – porous materials - pillared clays - colloids.

UNIT III

Light Emitting diodes, Semiconductor lasers, Photodetectors

Introduction – Light Emitting diodes (LED) – radiative transition - semiconductor laser diodes – Photoconductor, Photodiode – Avalanche Photodiode – Phototransistors.

UNIT IV

Solar cells

Introduction – basic principle – I-V characteristics – spectral response – Photovoltaic effect in a pn junction, Schottky barrier, thin film and cascade solar cells - materials and design considerations – application.

UNIT V

Optoelectronics Modulation and switching devices

Introduction – analog and digital modulation, Franz – Keldysh and stark effect modulators – quantum well electroabsorbtion modulators – electro optic modulators - optical switching and logic devices.

Reference Books:

1. Semi conducting Optoelectronics devices, Pallab Bhattacharya, prentice hall international editions, 1997.
2. Solid state physics, S O Pillai, 5th edition, New Age International (P) Ltd. (2004)
3. Optical Electronics, Ajay Ghatak & K.Thiyagarajan, Cambridge University Press, 1994.
4. Solid State physics, M A Wahab, Narosa Publishing House, 2005.
5. Physics of Semi conducting devices, S M sze, 2nd Edition, John – Wiley &Sons, 2005.
6. Optoelectronics, Jasprit Singh, McGrew Hill international Editors, 1996.
7. Semiconductor Optoelectronics, Jasprit Singh, McGrew Hill International Editors, 1996.