PROPOSED SYALLABUS AS PER UGC

CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

MSc PHYSICS (2018-2020)

GUIDELINES FOR CHOICE BASED CREDIT SYSTEM IN M. Sc. PHYSICS

1. Preamble

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, besides governance and other matters. The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. However, due to lot of diversity in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation and grading system. While the HEIs must have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi and teaching–learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students. Presently the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. The conversion from marks to letter grades and the letter grades used vary widely across the HEIs in the country. This creates difficulty for the academia and the employers to understand and infer the performance of the students graduating from different universities and colleges based on grades. The grading system is considered to be better than the conventional marks system and hence it has been followed in the top institutions in India and abroad. So it is desirable to introduce uniform grading system. This will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students. To bring in the desired uniformity, in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated these guidelines.

2. Applicability of the Grading System

These guidelines shall apply to all undergraduate and postgraduate level degree, diploma and certificate programs under the credit system awarded by the Central, State and deemed to be universities in India.

3. DEFINITIONS OF KEY WORDS:

3.1. **Academic Year**: Two consecutive (one odd + one even) semesters constitute one academic year.

3.2. **Choice Based Credit System (CBCS):** The CBCS provides choice for students to select from the prescribed elective and skill courses. A student needs to select **two elective papers** offered by the Department in which he/she is doing core course. This shall be part of core programme during third and fourth semester. Each student has to complete **four skill courses;** two within the Department and two from other Department within the college or from the other college/Universities approved by college.

3.3. Course: Usually referred to, as 'papers' is a component of a programme. All courses need not carry the same weight. The courses should define learning objectives and learning outcomes. A course may be designed to comprise lectures/ tutorials/laboratory work/ field work/ project work/ self-study etc. or a combination of some of these.

3.4. Credit Based Semester System (CBSS): Under the CBSS, the requirement forwarding a degree is prescribed in terms of number of credits to be completed by the students.

3.5. **Credit Point**: It is the product of grade point and number of credits for a course.

3.6. Credit: 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 period of teaching (lecture or tutorial) or two periods of practical work/field work per week.

3.7. Cumulative Grade Point Average (CGPA): It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.

3.8. Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale.

3.9. Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by letters O, A^+, A, B^+, B, C, P and F.

3.10. Programme: An educational programme leading to award of the Postgraduate Degree in the Core subject in which he/she is admitted.

3.11. Semester Grade Point Average (SGPA): It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.

3.12. **Semester**: Each semester will consist of 15-18 weeks of academic work equivalent to 90 actual teaching days. The odd semester may be scheduled from July to November/ December and even semester from December/January to May. Odd semester University examination shall be during <u>last week of November/ first week of December and even semester University examination shall be during first/ second week of May.</u> The Department shall conduct the Practical examinations with a board of internal and external examiners prior to commencement of end semester theory examination.

3.13. Transcript or Grade Card or Certificate: Based on the grades earned, a statement of grades obtained shall be issued to all the registered students after every semester. This statement will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester.

4. Semester System and Choice Based Credit System

The Indian Higher Education Institutions have been moving from the conventional annual system to semester system. Currently many of the institutions have already introduced the choice based credit system. The semester system accelerates the teaching-learning process and enables vertical and horizontal mobility in learning. The credit based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. The choice based credit system provides a 'cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning, It is desirable that the HEIs move to CBCS and implement the grading system.

5. Types of Courses:

Courses in a programme may be of three kinds: Core, Elective and Foundation.

5.1. Core Course

There may be a Core Course in every semester. This is the course which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

5.2. Elective Course

Elective course is a course which can be chosen from a pool of papers. It may be:

- Supportive to the discipline of study.
- Providing an expanded scope.
- Enabling an exposure to some other discipline/domain.
- Nurturing student's proficiency/skill.

An elective may be "Generic Elective" focusing on those courses which add generic proficiency to the students. An elective may be "Discipline centric"or may be chosen from an unrelated discipline. It may be called an "Open Elective."

5.3. Foundation Course:-

The Foundation Courses may be of two kinds: Compulsory Foundation and Elective foundation. "Compulsory Foundation" courses are the courses based upon the content that leads to Knowledge enhancement. They are mandatory for all disciplines. Elective Foundation courses are value-based and are aimed at man-making education.

6. Examination and Assessment

The HEIs are currently following various methods for examination and assessment suitable for the courses and programmes as approved by their respective statutory bodies. In assessing the performance of the students in examinations, the usual approach is to award marks based on the examinations conducted at various stages (sessional, mid-term, end-semester etc.,) in a semester. Some of the HEIs convert these marks to letter grades based on absolute or relative grading system and award the grades. There is a marked variation across the colleges and universities in the number of grades, grade points, letter grades used, which creates difficulties in comparing students across the institutions. The UGC recommends the following system to be implemented in awarding the grades and CGPA under the credit based semester system.

6.1. Letter Grades and Grade Points:

i. Two methods -relative grading or absolute grading– have been in vogue for awarding grades in a course. The relative grading is based on the distribution (usually normal distribution) of marks obtained by all the students of the course and the grades are awarded based on a cut-off marks or percentile. Under the absolute grading, the marks are converted to grades based on pre-determined class intervals. To implement the following grading system, the colleges and universities can use any one of the above methods.

ii. The UGC recommends a 10-point grading system with the following letter grades as given below:

Table 1: Grades and Grade Points

Letter Grade	Grade Point
O (Outstanding)	10
A^{+}(Excellent)	9
A(Very Good)	8
B^{+}(Good)	7
B(Above Average)	6
C(Average)	5
P (Pass)	4
F(Fail)	0
Ab (Absent)	0

Grade Point assignment

= and > 95 % marks Grade Point 10.0
90 to less than 95 % marks Grade Point 9.5
85 to less than 90 % marks Grade Point 9.0
80 to less than 85 % marks Grade Point 8.5
75 to less than 80 % marks Grade Point 8.0
70 to less than 75 % marks Grade Point 7.5
65 to less than 70 % marks Grade Point 7.0
60 to less than 65 % marks Grade Point 6.5
55 to less than 60 % marks Grade Point 6.0
50 to less than 55 % marks Grade Point 5.5
45to less than 50 % marks Grade Point 5.0
41 to less than 45 % marks Grade Point 4.5
= to 40 % marks Grade Point 4.0

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

iv. For non credit courses 'Satisfactory' or "Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

v. The Universities can decide on the grade or percentage of marks required to pass in a course and also the CGPA required to qualify for a degree taking into consideration the recommendations of the statutory professional councils such as AICTE, MCI, BCI, NCTE etc.,

vi. The statutory requirement for eligibility to enter as assistant professor in colleges and universities in the disciplines of arts, science, commerce etc., is a minimum average mark of 50% and 55% in relevant postgraduate degree respectively for reserved and general category. Hence, it is recommended that the cut-off marks for grade B shall not be less than 50% and for grade B^{+}, it should not be less than 55% under the absolute grading system. Similarly cut-off marks shall be fixed for grade B and B^{+} based on the recommendation of the statutory bodies (AICTE, NCTE etc.,) of the relevant disciplines.

6.2 Fairness in Assessment:

Assessment is an integral part of system of education as it is instrumental in identifying and certifying the academic standards accomplished by a student and projecting them far and wide as an objective and impartial indicator of a student's performance. Accordingly the Departments of the Faculty of Science resolve the following:

a. All internal assessments shall be open assessment system only and that are based on Quizzes, term test and seminar.

b. Attendance shall carry the prescribed marks in all papers and Practical examination internal assessment.

c. In each semester as far as possible, two out of four theoretical component University examinations shall be undertaken by external examiners from outside the university conducting examination, who may be appointed by the competent authority.

6.3 Grievances and Redressal Mechanism

a. The students will have the right to make an appeal against any component of evaluation. Such appeal has to be made to the Head/Principal of the College or the Chairperson of the University Department concerned as the case may be clearly stating in writing the reason(s) for the complaint / appeal.

b. The appeal will be assessed by the Chairman and he/she shall place before the Grievance Redressal Committee (GRC), Chaired by the Dean, Faculty of Science, comprising all HODs of the Faculty and if need be Course Teacher(s) be called for suitable explanation; GRC shall meet at least once in a semester and prior to CCA finalization.

c. The Committee will consider the case and may give a personal hearing to the appellant before deciding the case. The decision of the Committee will be final.

7. Computation of SGPA and CGPA

The UGC recommends the following 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 the number of credits of all the courses undergone by a student, i.e

SGPA $(S_i) = \Sigma(C_i \times G_i) / \Sigma C_i$

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 taking into account all the courses undergone by a student over all the semesters of a programme, i.e.

CGPA = $\Sigma(C_i \times S_i) / \Sigma C_i$

where Si is the SGPA of the ith semester and Ci is the total number of credits in that semester.

iii. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

8. Illustration of Computation of SGPA and CGPA and Format for Transcripts

i. Computation of SGPA and CGPA

Illustration for **SGPA**

Course	**Credit**	**Grade letter**	**Grade point**	**Credit Point**
Course 1	4	A	8	4 X 8 = 32
Course 2	4	B^+	7	4 X 7 = 28
Course 3	4	B	6	4 X 6 = 24
Course 4	4	O	10	4 X 10 = 40
Course 5	4	C	5	4 X 5 = 20
Course 6	4	B	6	4 X 6 = 24
Total	**24**			**168**

Thus, **SGPA =168/24 =7.00**

Illustration for **CGPA**

Semester 1	**Semester 2**	**Semester 3**	**Semester 4**
Credit : 24 SGPA: 7.00	Credit : 24 SGPA:6.58	Credit : 24 SGPA:6.65	Credit : 24 SGPA: 6.89

Thus, **CGPA =** $\frac{24 \times 7.00 + 24 \times 6.58 + 24 \times 6.65 + 24 \times 6.89}{96} = \mathbf{6.78}$

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

Evaluation scheme

(A) Theory (100 marks)

The performance of the student will be evaluated through two components

(1) **CCA** (continuous comprehensive assessment)______30 marks

(2) **ESE** (End semester examination)________________70 marks

Total______________100 marks

(1) Format for CCA (30 marks)

CCA will have the following components

(a) **Two quiz** of 30 marks each of 1 hour duration (total of 60 marks)
Quiz will include multiple choice questions, fill in the blank, true or false and short answer questions

(b) **One Subjective test** (20 marks)

(c) **Attendance*** (10 marks)
Total marks =90
(The scored marks will be then converted out of 30)

(2) Format for ESE (70 marks)

The paper for ESE examination will be divided in to three parts

(a) **Part A:** ten short answer type questions (20-30 words approx) of 2 marks each, two questions from each unit (total of 20 marks)

(b) **Part B:** Five short answer type questions (250 words approx) of 4 marks each, one question from each unit with internal choice (total of 20 marks)

(c) **Part C:** Five descriptive answer type questions, one from each unit. Each questions will carry 10 marks each, student is required to answer any three out of these five questions (total of 30 marks)

(B) Practical

The **CCA** (30 marks) will be based on **attendance*** (10 marks) and **practical records** (20 marks).

The **ESE** (70 marks) where in the marks distribution will be as under

DURATION OF EXAM: 04 Hours

(i) EXPERIMENT: 40

1. Formula or theory and explanation of symbols used: 05
2. Block Diagram/ Diagram or Circuit Diagram: 05
3. Observations: 15
4. Calculations: 10
5. Results with units and graphs: 05

(ii) VIVA-VOCE: 30

TOTAL 70

(C) PROJECT (100 marks)

CCA : 30

ESE : 70

1. Contents: 15
2. Sequence of content 15
3. Project report 15
4. Presentation 25

***Attendance marks:** Each student will have to attend a minimum of 75% Lectures / Tutorials / Practicals. A student having less than 75% attendance will not be allowed to appear in the End-Semester Examination (ESE). Attendance shall have 10 marks and will be awarded by following the system proposed below:

Those having greater than 75% attendance (for those participating in Co-curricular activities, 25% will be added to per cent attendance) will be awarded CCA marks as follows:-

75% to less than 80%	=	2 marks
80% to less than 85%	=	4 marks
85 to less than 90%	=	6 marks
90% to less than 95%	=	8 marks
> =95%	=	10 marks

Condonation of Shortage of attendance shall be governed in accordance with the provisions in the Act and Statute of the University vide Ordinance 78 to Ordinance 80 as amended from time to time.

SEMESTER-WISE NOMENCLATURE OF THEORY PAPERS/ PRACTICALS/ SKILL COURSES

SEMESTER I

COARSE TYPE	COARSE CODE	NAME OF COURSE	LEC./ TUT./ PRAC. PER WEEK $	NO. OF CREDITS	CCA #	ESE *	TOTAL
Core Course 1	MSPH111	CLASSICAL MECHANICS	4-0-0	4	30	70	100
Core Course 2	MSPH112	MATHEMATICAL PHYSICS	4-0-0	4	30	70	100
Core Course 3	MSPH113	COMPUTATIONAL PHYSICS	4-0-0	4	30	70	100
Core Course 4	MSPH114	SEMICONDUCTOR DEVICES AND CIRCUITS	4-0-0	4	30	70	100
Core Course 5	MSPH121	COMPUTATIONAL LAB	0-0-8	4	30	70	100
Core Course 6	MSPH122	ELECTRONICS LAB	0-0-8	4	30	70	100
Skill Course 1	MSPHSC131 (A/B)!!	(A) INTRODUCTION TO ASTROPHYSICS (B) INTRODUCTION TO NONLINEAR OPTICS	2-0-2	-	-	-	-
TOTAL				**24**	**180**	**420**	**600**

$ Lectures/Tutorials/Practical per week
 # Continuous Comprehensive Assessment

*** End Semester Examinations**
!! Choose A or B

SEMESTER II

COARSE TYPE	COARSE CODE	NAME OF COURSE	LEC./ TUT./ PRAC. PER WEEK$	NO. OF CREDITS	CCA#	ESE*	TOTAL
Core Course 1	MSPH211	DIGITAL ELECTRONICS AND MICROPROCESSOR	4-0-0	4	30	70	100
Core Course 2	MSPH212	QUANTUM MECHANICS-I	4-0-0	4	30	70	100
Core Course 3	MSPH213	SOLID STATE PHYSICS	4-0-0	4	30	70	100
Core Course 4	MSPH214	STATISTICAL AND PLASMA PHYSICS	4-0-0	4	30	70	100
Core Course 5	MSPH221	GENERAL PHYSICS AND SOLID STATE LAB	0-0-8	4	30	70	100
Core Course 6	MSPH222	DIGITAL ELECTRONICS AND MICROPROCESSOR LAB	0-0-8	4	30	70	100
Skill Course 2	MSPHSC232	ELECTRONICS INSTRUMENTATION	2-0-2	-	-	-	-
TOTAL				**24**	**180**	**420**	**600**

$ Lectures/Tutorials/Practical per week
 # Continuous Comprehensive Assessment
*** End Semester Examinations**

SEMESTER III

COARSE TYPE	COARSE CODE	NAME OF COURSE	LEC./ TUT./ PRAC. PER WEEK $	NO. OF CREDITS	CCA #	ESE *	TOTAL
Core Course 1	MSPH311	CLASSICAL ELECTRODYNAMICS	4-0-0	4	30	70	100
Core Course 2	MSPH312	QUANTUM MECHANICS-II	4-0-0	4	30	70	100
Core Course 3	MSPH313	NUCLEAR PHYSICS-I	4-0-0	4	30	70	100
Core Course 4	MSPH314 (A/B)!!	ELECTIVE PAPER –I	4-0-0	4	30	70	100
Core Course 5	MSPH321	GENERAL PHYSICS LAB	0-0-8	4	30	70	100
Core Course 6	MSPH322	NUCLEAR PHYSICS LAB	0-0-8	4	30	70	100
Skill Course 3	MSPHSC333 (A/B)!!	(A). RENEWABLE ENERGY RESOURSES (B). INTRODUCTION TO PROGRAMMING IN C-LANGUAGE AND COMPUTER SIMULATION IN PHYSICS	2-0-2	-	-	-	-
TOTAL				**24**	**180**	**420**	**600**

$ Lectures/Tutorials/Practical per week
 # Continuous Comprehensive Assessment
*** End Semester Examinations**

!! Choose either A or B

SEMESTER IV

COARSE TYPE	COARSE CODE	NAME OF COURSE	LEC./ TUT./ PRAC. PER WEEK$	NO. OF CREDITS	CCA#	ESE*	TOTAL
Core Course 1	MSPH411	NUCLEAR PHYSICS-II	4-0-0	4	30	70	100
Core Course 2	MSPH412	ATOMIC AND MOLECULAR SPECTROSCOPY	4-0-0	4	30	70	100
Core Course 3	MSPH413	NANOMATERIALS	4-0-0	4	30	70	100
Core Course 4	MSPH414 (A/B)!!	ELECTIVE PAPER-II	4-0-0	4	30	70	100
Core Course 5	MSPH421 (A/B)!!	ELECTIVE PAPER LAB	0-0-8	4	30	70	100
Core Course 6	MSPH422	PROJECT WORK	0-0-8	4	30	70	100
Skill Course 4	MSPHSC434	BASICS OF NANOSCIENCE	2-0-2	-	-	-	-
TOTAL				**24**	**180**	**420**	**600**

$ Lectures/Tutorials/Practical per week
 # Continuous Comprehensive Assessment
*** End Semester Examinations**
!! Choose either A or B

ANUXURE- B1(1)

SYLLABUS OF MSc. I YEAR (I AND II SEMESTERS)

SUBJECT: PHYSICS

(2018-2019)

MSc. Physics (I Semester)

Core Course 1

MSPH111: CLASSICAL MECHANICS

Unit I

Langrangian Dynamics: Constraints, Generalized coordinates, Concept of virtual work, D'Alembert principle, Langrange equation from D'Alambert principle, Velocity dependent potential, Expression for kinetic energy of a system in terms of Generalized coordinates, Cyclic coordinates, Symmetry properties and conservation theorems.

Unit II

Hamiltonian dynamics: Hamiltonian function H and conservation of energy: Jacobi's integral and its significance, Hamilton's equation, Routhian.

Hamiltons variation principle, Derivation of Langrange equation, Extension of Hamilton's Principle, to non-holonomic system, A hoop rolling without slipping on an inclined plane, Modified Hamilton's Variation principle, Derivation of Hamilton's equation from variation principle, Δ- variations, Principle of least actions in various forms.

Unit III

The Two Body Central Force Problem: Central force and motion in a plane, Reduction of a two body central force to equivalent one body problem, Equation of motion and first integral, Differential equation for an orbit, Equivalent one dimensional problem and classification of orbits for some specific potential.

Integral power law potential, Virial theorem, Relation between kinetic and potential energy.

Keplers Problems: Equation of orbit and the kind of the orbit, Motion in time.

Unit IV

The kinematics of rigid body motion: Independent co-ordinate of a rigid body, Orthogonal transformation, Formal properties of transformation matrix, Eular angles, Eular's theorem, Finite rotation, Infinitesimal rotations (contact transformation).

Angular momentum, Moment of inertia tensor, Product of inertia, Inertia tensor, Principal moment of inertia: Principal axis, Kinetic energy of motion of a rigid body about a point.

Unit V

Canonical transformation and Hamilton Jacobi theory: Canonical transformation, Legendre transformation, Generating functions, Conditions for canonical transformation, Bilinear invariant condition.

Poisson's brackets, Langrange brackets, Invariance of Poission bracket under canonical transformation, Angular momentum Poission bracket relation.

Hamilton Jacobi equation for Hamilton's principal function, Harmonic oscillator problem by Hamilton Jacobi method, Hamilton's characteristic function.

Suggested Readings:

1. H. Goldsteen: *Classical Mechanics*, Narosa Publishing House, 2001.
2. N. C. Rana and P. S. Joag: *Classical Mechanics*, Tata Mc-Graw Hill, New Delhi, 1991.
3. J. C. Upadhyaya: *Classical Mechanics*, Himalaya Publishing, 2006.
4. P. V. Panat: *Classical Mechanics*, Narosa Publishing House, 2000.
5. S. L. Gupta, V. Kumar, H. V. Sharma: *Classical Mechanics*, Pragati Prakashan, Meerut, 2009.

MSc. Physics I Semester

Core Course 2

MSPH112: MATHEMATICAL PHYSICS

Unit I

Complex Variables: Analytical functions, Cauchy Riemann conditions, Cauchy's integral theorem, Cauchy's integral formula, Taylor and Laurent's Series expansions, Cauchy's residue theorem, Simple examples of contour integration.

Unit II

Fourier and Laplace Transforms: Fourier transform, Convolution theorem, Laplace transforms, Laplace transform of derivatives, Substitution properties of Laplace transform, Properties of gamma function, Error function and Dirac delta functions.

Unit III

Curvilinear Coordinates: Orthogonal coordinate systems, Gradient, Curl, Divergence and Laplacian in orthogonal coordinate systems, Spherical, Polar and Cylindrical co-ordinates, Poisson's and Laplace Equations, Green's theorem.

Probability Theory: Elementary probability theory, Random variables, Binomial, Poisson and normal distributions.

Unit IV

Coordinates Transformation in N- dimensional Space: Contravariant and covariant tensor, Jacobian, Relative tensor, Pseudo tensors (Example: charge density, angular momentum), Riemann space(Example: Euclidean space and 4D Minkowski space), Christoffel symbols, Transformation of Christoffel symbols, Covariant differentiation ,Ricci's theorem , Divergence, Curl and Laplacian tensor form, Stress and strain tensors, Hook's law in tensor form.

Unit V

Special Functions: Series solution of linear differential equations with variable coefficients, Legendre, Bessel, Hermite, Laguerre, Associated Laguerre polynomials and their generating functions, Recurrence relations, Orthogonal properties and Rodrigue's formula.

Suggested Reading:

1. B.D. Gupta: *Mathematical Physics*, Vikas Publication House, 1986.
2. H.K. Das: *Advanced Engineering Mathematics*, S. Chand Pub., 2008.
3. George Arfken and H.J. Weber: *Mathematical Physics*, Academic Press, 2005.
4. B.S. Rajput: *Mathematical Physics,* Pragti Prakashan, Meerut, 1997.
5. L.A. Pipes: *Applied Mathematics for Engineers & Physicists*, Mc-Graw Hill, 1970.
6. M.C. Potter and J.L Goldberg: *Mathematical Methods,* Prentice Hall of India, 1978.

MSc. Physics I Semester

Core Course 3

MSPH113: COMPUTATIONAL PHYSICS

Unit I

General Concepts of Programming : Algorithm, Flowchart, Programming language, High level and low level language, Compiler, Errors in programs and their removal, Data, Record and file.

Numeric Computing: Process of numeric computing, Characteristics of numeric computing, Significant digits, Accuracy, Precision, Types of errors, Absolute error and relative error, Errors propagations, Conditioning and stability, Iterative process and its convergence, Error estimation.

Unit II

Programming with FORTRAN: Constants and variables, Arithmetic operations, Built in functions, Input and output statements, FORMAT statement, Assignment statement, Expression, Relational and logical operator, Transfer of control, IF statements, GOTO statements, Do loop, Nested loop, Function and subroutines, COMMON and TYPE statement, Use of files, Writing and executing a FORTRAN program.

Unit III

Solution of Transcendental and Polynomial Equation in one Variable: Newton Raphson, Successive bisection, False position methods, Convergence of these methods.

Solution of Simultaneous Linear Equations: Gauss elimination method, Gauss elimination with pivoting, Gauss -Seidel method, Eigen value and Eigen vectors of matrices, Finding Eigen value and Eigen vector by Jacobi method and power method.

Unit IV

Solution of Ordinary Differentials Equations: Euler and Runga-Kutta Methods, Predictor-corrector method, Error estimates in these methods.

Numerical Differentiation: Differentiation of continuous function, Forward difference and central difference methods, Differentiations of tabulated functions

Numerical Integrations: Newton-Cotes method, Trapezoidal rule, Simpson's 1/3 and 3/8 rules, Guass - Quadrature Method, Error estimates.

Unit V

Curve Fitting: Interpolation, Polynomial forms, Linear interpolation, Lagrange interpolation, Newton interpolation, Interpolation with equidistance points, Regression, Fitting linear equation, Least square regression, Fitting transcendental equation and polynomial Function.

Simulation Methods : Random numbers, Generation of random numbers, Monte Carlo method of numerical Integration, Introduction to simulation and simulation methods, Monte Carlo simulation method, Molecular dynamics method.

Suggested Reading:

1. E. Balagurusamy: *Numerical Methods*, TMH, New Delhi, 2006
2. Suresh Chandra: *Computer Application in Physics with FORTRAN, BASIC and C, 2nd edtion.*, Narosa Publishing House, New Delhi, 2006.
3. E V Krishnamurthy and S K Sen: *Numerical Algorithms: Computations in Science and Engineering, 11th edition*, Affiliated East-West Press Private Limit., New Delhi, 2007.
4. Seymour Lipschutz and Arthur Poe: *Theory and Problems of Pragamming with Fortran, Schaum's Outline Series*, Mc-Graw Hill Comp., Singapore, 1982.
5. R.C. Verma: *Computer Simulation in Physics*, Anamaya Publishers, New Delhi, 2004.
6. K. P. N. Murthy: *Monte Carlo Methods in Statistical Physics*, University Press, Hyderabad, 2004.

M.Sc. Physics I Semester

Core Course 4

MSPH114: SEMICONDUCTOR DEVICES AND CIRCUITS

Unit I

Semiconductors: Elemental and compound semiconductor, Direct and indirect band gap, Non-degenerate and degenerate semiconductor, Generation and recombination of carriers, Types of recombination, Life time, Carrier drift and diffusion,

P-N Junction: Diffusion of impurities, Formation of junction, Electric field and potential, Junction capacitance, Diffusion capacitance, I-V characteristics, Switching and reverse recovery,

Unit II

Bipolar Junction Devices: Bipolar junction transistor, I-V characteristics, Switching action, Thyristors and UJT.

Metal semiconductor devices and FETs, Metal semiconductors barrier, Schottky effect, MOS diode, Energy band and I-V characteristics, MOSFET, LED: materials, Configurations and efficiency, LASER principle, Semiconductor and He–Ne lasers, PN junction solar cells.

Unit III

Feedback circuits: Feedback concept, positive and negative feedback, Barkhausen criterion, RC phase shift oscillator, Wein bridge oscillator, Hartley and Colpitt’s oscillators, Nyquist criterion, Multivibrators: astable, monostable and bistable multivibrator, UJT relaxation oscillator, Schmitt Trigger, 555 timer based astable multivibrator,

Unit IV

Differential amplifier: Dual input, Balanced output differential amplifier, DC analysis, CMRR, constant currents bias, Level translator, Block diagram of typical OP-Amp, Characteristic of OP-Amp, Open and closed loop configuration, Inverting and non-inverting amplifiers, Voltage series feedback, Effect of feedback on closed loop gain, Input resistance, Bandwidth, Total output voltage, Applications of OPAMP- sign changer, scale changer, adder, integrator, differentiator.

Active Filters: first and second order Butterworth filters- Low pass, High pass, band pass and band reject filters

Unit V

Controlled Rectification and Voltage Regulation: Half wave and full wave, SCR control, Current rating of SCR, DIAC and TRIAC, DIAC-TRIAC phase control circuits, Voltage regulation using transistors, OP-AMP voltage regulator and regulator IC's.

Suggested Reading:

1. S.M. Sze: *Physics of Semiconductor Devices*, 2^{nd} edition, Wiley India, 2004.
2. Ramkant A. Gayakwad*:* *Op-Amps and Linear Integrated Circuits*, PHI, New Delhi, 4^{th} Ed., 2004.
3. John P. Mckelvey: *Solid State and Semiconductor Physics*, Krieger Pub Co., Harper International Edition, 1966.
4. A.G. Milnes: *Semiconductor Device and Integrated Electronics*, Van Nostrand Reinhold Publisher, 1980.
5. John Gower: *Optical Communication Systems.*PHI, New Delhi, 2^{nd} Ed., 1993.
6. S.M. Zee: *Semiconductor Devices: Physics and Technology, 2^{nd} Ed.,* Wiley India, 2002.
7. Allen Mottershed: *Electronic Devices and Circuits*, PHI, 2005.

MSc. Physics I Semester

Core Course 5

MSPH121: COMPUTATIONAL PHYSICS LAB

List of Experiments:

1. Determination of roots by Newton's Rapshon method.
2. Determination of roots by Bisection method.
3. Determination of roots by False- Position method.
4. Numerical integration by Trepozoidal method.
5. Numerical integration by Simpson's 1/3 method.
6. Numerical integration by Simpson's 3/8 method.
7. Integration by Guass-Quadature method.
8. Solution of differential equation by Runga- Kutta second order method.
9. Solution of differential equation by Runga- Kutta fourth order method.
10. Using Monte-Carlo methods integrate numerically the given function of one variable.
11. Curve fitting by least square method.

MSc. Physics I Semester

Core Course 6

MSPH122: ELECTRONICS LAB

List of Experiments:

1. Study of effect of negative feedback on frequency response and input and output impedance of a BJT amplifier.
2. Study of wave shapes generated by astable multivibrator and determination time constant.

3. Study of differential amplifier and determination of CMRR.
4. Life time measurement by reverse recovery method.
5. Life time measurement by open circuit voltage decay (OCVD) method.
6. Sawtooth wave generation using UJT and determination of time constant.
7. Study of RC phase shift oscillator and measurement of time period.
8. First and second order low pass filters.
9. First and second order high pass filters.

MSc. (I Semester)

Skill Course –I(A)

MSPHSC131(A): INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS

Formation of Planets: Making of planets, Chemistry and Origin of Planets, Lunar eclipse, sun eclipse, Jupiter and Saturn, a different model.

Dead world in Solar System:- The moon's orbit, rotation, size and mass, The moon's physical properties, tides due to moon, moon's environment, craters, mercury's orbit, rotation, size, mass and density, mercury's environment and magnetic field.

Planet Earth: Mass, density, interior, age and magnetic field of Earth, Earth's Atmosphere with the extinction, ALBEDO, Green House effect, earth quack and mountain continental drift.

High energy Astrophysics: large scale distribution of matter and radiation in Universe, The Galaxies, star, stellar evaluation, the interstellar Media, Age of the Galaxy, Binary stars and stellar evaluation, white dwarf, Neutron stars and black hole.

X-ray binaries and γ-ray burst : Different types of binary stars; Importance of binary systems; Roche lobe overflow, Chandrasekhar limit, Accretion in Binary system, accretion disk, LMXBS, HMXBS, X-ray mission (elementary idea), γ-ray burst, GRB Telescopes (elementary idea), origin of cosmic rays.

Suggested Readings:

1. Stephen A. Gregory , Michael Zeilik and Elske V. Smith, Introductory Astronomy and Astrophysics, Saunders College Publishing, 1992
2. Micheal Zeilik, Astronomy the Evolving Universe, Cambridge University Press, 2002
3. E.W. Kolb and M.S. Turner, The Early Universe, Westview Press, 1994
4. Basu Baidyanath , Chattopadhyay Tanuka, Biswas Sudhindra Nath, An Introduction to Astrophysics, PHI publication, 2nd Edition, 2013
5. M.S. Longair, High energy Astrophysics, Cambridge University Press, 2006
6. Juhan Frank, Andrew king and Derek Raine, Accretion Power in Astrophysics, Cambridge University Press, 2002

7. Alain Mazure, Stephane Basa: Exploding Superstars, Understanding Supernovae and Gamma-Ray Bursts, Springer Praxis Books, 2009.

INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS LAB WORK

1. Determine outburst in LMXB'S/ HMXB'S using ASM curve (RXTE data).
2. Detection of Quasi Periodic Oscillation (QPO) in light curve of X-ray Binaries.
3. Determine average magnetic field of celestial compact object using HEASOFT.
4. Determination of Temperature of GRB.
5. Determination of frequency of fluctuation in light curve of GRB.
6. Determination of delay time (lags) between energy bands of GRBs.
7. Determination of multi peaks in light curve of GRB.
8. Measurement of depth of craters of the moon by telescope.
9. Measurement of counting of sunspots over the month by telescope.
10. Measurement of temperature of the sun by Pyrometer.

MSc. (I Semester)

Skill Course –I(B)

MSPHSC131(B): INTRODUCTION TO NONLINEAR OPTICS

Lasers: Gas lasers, He-Ne, Solid state lasers: Ruby, Nd: YAG, Ti –Sapphire, Organic dye laser, Semiconductor lasers: Diode laser, p-n-junction laser, GaAs Laser

Introduction to Nonlinear Optics: Refractive index, Frequency and intensity dependent refractive index, Wave propagation in an anisotropic crystal, Polarization response of materials to light, Second harmonic generation, Sum and difference frequency generation, Phase matching.

Multiphoton Processes: Two photon process, Theory and experiment , Three photon process parametric generation of light, Oscillator, Amplifier, Stimulated Raman scattering, Intensity dependent refractive index, Optical Kerr effect, Photorefractive, Electron optic effects.

Nonlinear Optical Materials: Basic requirements, Inorganics, Borates, Organics, Urea, Nitro aniline, Semi organics, Thiourea complex, Kurtz test, Laser induced surface damage threshold.

Fiber Optics: Step Graded index, Fibers wave propagation, Fiber modes , Single and multimode fibres, Numerical aperture, Dispersion, Fiber bandwidth, Fiber loss, Attenuation coefficient, Material absorption.

Suggested Readings:

1. B.B. Laud, Lasers and Nonlinear Optics, New Age International (P) Ltd., New Delhi, 1991.
2. Robert W. Boyd, Nonlinear Optics, Academic Press, New York, 2003.
3. Govind P. Agarwal, Fiber-Optics Communication Systems, John Wiley & Sons, Singapore 2003.
4. William T. Silvast, Laser Fundamentals, Cambridge University Press, Cambridge, 2003.
5. Nonlinear Optics, Basic Concepts D.L. Mills, Springer, Berlin, 1998.

INTRODUCTION TO NONLINEAR OPTICS LAB WORK

1. Study of characteristics of LED and PIN Photo Detector.
2. Study of frequency response of optical receiver.
3. To study attenuation in optical fibers.
4. To find numerical aperture of optical fibers.
5. Study of noise in an optical receiver.
6. Diffraction of light by cross wire/fine wire mesh.
7. Gaussian nature of laser beam/beam spot measurement/ divergence measurement.
8. Characteristics of light dependent resistor (LDR), LED, photo diode and photo transistor, solar cell.

MSc. Physics (II Semester)

Core Course 1

MSPH211: DIGITAL ELECTRONICS AND MICROPROCESSOR

Unit I

Digital Circuits: Logic gates, DeMorgans theorems, Universal Gates, Karnaugh Maps,
Various logic families: Transistor as a switch, Fan-in and Fan-out, Propagation delay, Tri-state logic, RTL, DTL, TTL, NMOS, CMOS.
Flipflops, One bit memory, RS flipflop, D flipflop, JK flipflop, Edge triggered, Preset and Clear.

Unit II

Counters and Registers: Asynchronous counters, up-down counter, Synchronous counter, MOD counters, Registers, Shift registers, Parallel loading, Universal shift registers, Applications of shift registers: Serial to parallel convertor, Parallel to serial convertor, Digital to analog convertor(D/A), Analog to digital convertor(A/D).

Unit III

Micro- Computer Hardware: Semiconductor memories, RAM, SRAM, DRAM, ROM, CPU: Instruction register and decoder, ALU, Control unit, Buses: Data, Address and control buses, Minimum microcomputer configuration, Interrupts, Concept of I/O mapped and memory mapped I/O.

Unit IV

8085 Microprocessor: Microprocessor 8085: Organization of 8085 microprocessor, Fetch and execution of instruction, Bus multiplexing, Interrupts : Maskable and non-maskable, Call locations, Interrupt service subroutine, Instruction set of 8085 Microprocessor: Data transfer group, Arithmetic group, Logical group, Branches group, Stack related instructions, Mnemonics and operation codes, Addressing modes: Direct, Indirect, Immediate, Indexed and relative, Assembly language programming.

Unit V

Data Transfer, Peripheral devices and Interfacing: Types of data transfer, Direct Memory Access, 8257 DMA controller, LED displays, I/O ports, 8255 programmable peripheral interface, 8253 programmable interval timer, 8279 keyboard-display interface, 8259 Programmable interrupt controller.

Suggested Reading:

1. A.P. Malvino and D.P. Leach: *Digital Principle and Applications 4th Ed.,* TMH, 1975.
2. B. Ram: *Fundamental of Microprocessors and Microcomputers*, Dhanpat Rai Publications, New Delhi, 2010.
3. R. S. Gaonkar: *Microprocessor Architecture Programming and Applications with the 8085,* CBS Publishers, 2011
4. M. Morris Mano: *Digital Design, 4th Ed*., Pearson, 1992.

MSc. Physics II Semester

Core Course 2

MSPH212: QUANTUM MECHANICS-I

Unit I

General Formalism: Historical background, Stern-Gerlach experiment leading to concept of vector space, Ket and bra notation for vector space, Inner product, Norm of a vector, Orthonormality and linear independence, Basis and dimension, Outer product, Projection operator, Completeness (closure property), Hilbert space, Operator, Hermition operator, Eigen value and eigen function, Representation theory, Change of basis, Unitary operator, Matrix elements, Unitary transformation, Diagnolisation, Coordinate and momentum representation.

Unit II

Measurements in Quantum Mechanics: Expectation values, Compatible and incompatible observable, Base kets as simultaneous eigen kets of maximal set of commuting observable, Examples, Heisenberg uncertainty principle, Gaussian wave packet, Schrödinger picture, Heisenberg picture and interaction picture.

Invariance Principle and Conservation Laws: Symmetry and conservation laws, Displacement in space-conservation of linear momentum, Displacement in time –conservation of energy, Rotations in space-conservation of angular momentum, Space- inversion parity.

Unit III

Solution of Schrodinger Equation: One dimensional simple harmonic oscillator: Eigen function and Eigen value by solving Schrödinger equation and also by operator method, Creation and annilation operators.

Operators for Orbital Angular Momentum: Orbital angular momentum operators L^2, L_x, L_y and L_z, Spherical harmonics, Solution of Schrödinger equation for Hydrogen atom-energy levels and stationary state wave functions.

Unit IV

Angular Momentum: Spin angular momentum and total angular momentum, Ladder operators, Matrix representation of Operators J_x, J_y, J_z, and J^2, Pauli spin matrices, Addition of two angular momentums, Clebsch- Gorden coefficients, Selection Rules and simple applications.

Unit V

Approximation Methods: WKB approximation: Principle, WKB wave function, Criterion for the validity of the approximation, Connection formulas, Applications to the one dimensional bound system, Penetration of potential barrier. Variational method: Principle and applications to linear harmonic oscillator, Helium atom. Time independent perturbation theory: Non degenerate case, Application to anharmonic oscillator (X^4) and linear harmonic oscillator, Degenerate case: Application to linear Stark effect and Zeeman effect in the Hydrogen atom.

Suggested Reading:

1. J.J. Sakurai: *Modern Quantum Mechanics,* Addison Wesley, 2010.
2. V.K. Thankappan: *Quantum Mechanics, 2nd edition,* New Age International (P) Limited, Publishers, New Delhi, 2010.
3. A. Ghatak and S. Loknathan: *Quantum Mechanics: Theory and Application,* 4th edition, Macmillan, 1999.
4. D.J. Griffith: *Introduction to Quantum Mechanics,2nd edition,* Pearson Education, 2005.
5. L.I. Schift: *Quantum Mechanics, 3rd edition,* Mc-Graw Hill, 1968.
6. B.S. Rajput: *Advanced Quantum Mechanics,* Pragti Prakashan, Meerut, 1994.

MSc. Physics II Semester
Core Course 3
MSPH213: SOLID STATE PHYSICS

Unit I

Crystal Physics: Diffraction of waves by crystals, Reciprocal lattice and its application to diffraction technique, Laue, Powder and rotating crystal method, Crystal structure factor and atomic form factor.
Lattice Vibrations: Quantization of elastic waves, Phonon momentum and inelastic scattering by phonons.
Defects in Crystal: Point defects, Colour centres, F-centres, Line defects and planer defects, Role of dislocations in crystal growth.

Unit II

Ferroelectrics: Classification of ferroelectric crystals, Theory of the ferroelectric displacive transitions: Polarization catastrophe, Soft optical phonon, Thermodynamics of ferroelectric transition, Ferroelectric domains, Antiferroelectric, Piezoelectric and pyroelectric material.
Phase Transition: First and second order transition, Long range order, Short range order and Bragg William model.

Unit III

Superconductivity: Basic phenomena, Meissner effect, Critical field, Type- I and Type- II superconductors, Heat capacity, Isotope effect, London equations, Coherence length, BCS theory of superconductivity, Flux quantization, Normal tunneling, dc and ac Josephson Effect, SQUID, High temperature superconductors.

Unit IV

Ferromagnetism: Weiss theory of ferromagnetism, Exchange interaction: Heisenberg model, Ferromagnetic domains, Origin of domains, Anisotropy energy, Bloch wall, Curie-Weiss law for susceptibility, Antiferromagnetic, Ferrimagnetic order, Spin wave and magnons.

Unit V

Band Theory of Solids: Electrons in periodic lattice, Bloch theorem, Nearly free electron model, Tight-binding approximation, Fermi surface, de Hass-Van Alphen effect, Cyclotron resonance, Magneto-resistance, Quantum Hall effect.
Optical Properties: Refractive index, Electronic polarization, Optical absorption, Photoconductivity, Relationship between absorption coefficient and band gap recombination.

Suggested Reading:

1. C. Kittel: *Introduction of Solid State Physics*, 7th edition, John Wiley & Sons, 2004.
2. J.P. Shrivastava: *Elements of Solid State Physics, 2nd edition,* PHI, New Delhi, 2006.
3. L.V. Azaroff*: Introduction to Solids*, TMH edition, 1996.
4. N.W. Ashcroff N.D. Mermin: *Solid State Physics,* Holt, Rinehart and Winston, 1976.
5. A.J. Dekker: *Solid State Physics*, Prentice Hall, 1957.

MSc. Physics II Semester

Core Course 4

MSPH214: STATISTICAL AND PLASMA PHYSICS

Unit I

Ensembles Theory and Boson gas: Micro canonical, Canonical and grand canonical ensembles, Phase spacing of classical system, Liouvilles theorem and its consequence, Quantum state and phase space, Chemical potential near absolute zero, Thermodynamics behavior of an ideal Boson gas, Bose- Einstein condensation, Liquid ^{4}He, Phase relation of Helium, Quasiparticles and superfluidity of ^{4}He, Superfluid phases of ^{3}He.

Unit II

Fermi Gas: Strongly degenerate Fermions gas and its thermodynamics, Ground state of Fermi gas, density of states, heat capacity of electron gas, Fermi gas in metals, Magnetism of free electron gas in weak and strong magnetic field, Landu diamagnetism, Ultra cold Fermi gas, White dwarf stars, Nuclear matter, Statistical model of an atom.

Unit III

Basic Properties and Occurrence of Plasma: Definition of plasma, Criteria for plasma behavior, Plasma oscillation, Quasi-neutrality and Debye Shielding, Plasma parameters, Natural occurrence of plasma, Astrophysical plasmas, Plasma in Magnetiosphere and Ionosphere, Plasma production and diagnostics, Thermal ionization, Saha equation, Brief discussion of methods of laboratory plasma production, Steady stage glow discharge, Microwave breakdown and induction discharge, Double plasma machine, Elementary ideas about plasma diagnostics, Electrostatic and magnetic probes.

Unit IV

Plasma Fluid Equations: Fluid equations; Convective, Two fluid and single fluid equations, Fluid drifts perpendicular to B diamagnetic drift.

Diffusion and Resistivity: Collision and diffusion parameters, Decay of a plasma by diffusion, Ambipolar diffusion, Diffusion across magnetic field, Collision in fully ionized plasma, Plasma resistivity, Diffusion in fully ionized plasmas, Solution of diffusion equation.

Unit V

Equilibrium and Stability: Hydromagnetic equilibria, Concept of magnetic pressure, Equilibrium of a cylindrical pinch, Benner pinch, Diffusion of magnetic field into plasma, Classification instabilities, Two stream instability, Gravitational instability. Resistive drift waves.

Suggested Reading:

1. R.K. Pathria: *Statistical Physics*, Elsevier India Pvt. Ltd., New Delhi, 2011.
2. F. Reif: *Statistical Physics (Vol. V)*, TMH, New Delhi, 2006.
3. David J. Griffiths: *Introduction to Electrodynamics*, Pearson Education, Delhi, 2003.
4. J.D. Jackson: *Classical Electrodynamics*, *2nd edition*, Wiley Eastern Ltd., New York, 1985.
5. Satya Prakash: *Electromagnetic Theory and Electrodynamics*, Kedar Nath Ram Nath & Co., Meerut, 1995.

MSc. Physics II Semester

Core Course 5

MSPH221: GENERAL PHYSICS AND SOLID STATE LAB

List of Experiments:

1. To determine Plank's constant.
2. To determine paramagnetic susceptibility of given material (solution).
3. To determine Young's modulus of glass by Cornu's method.
4. To determine critical potentials with the help of Franck Hertz's experiment.
5. Study of coupled oscillators and finding the beat frequency.
6. Verification of Cauchy's Dispersion relation and calculation of Cauchy's constant.
7. To determine electrical resistivity of semiconductor by Four Probe method.
8. Study of absorption coefficient of $KMnO_4$.
9. Verification of Hartmann Dispersion relation.

MSc. Physics II Semester

Core Course 6

MSPH222: DIGITAL ELECTRONICS LAB.

List of Experiments:

1. Study of RC phase shift oscillator.
2. Study of square wave generator.
3. Study of Schmitt trigger.
4. Study of flip flops.
5. Study of half adder and full adder.
6. Study of half and full subtractor.
7. Study of shift registers.
8. Study of counters.

9. Study of MOD counters.
10. Assembly language programming on 8085 microprocessor: Data transfer using direct and indirect addressing, Addition, Subtraction.
11. Assembly language programming on 8085 microprocessor: Multiplication, Division, Array Addition, Largest and smallest from a set of numbers.

MSc. (II Semester)

Skill Course –II

MSPHSC232: ELECTRONICS INSTRUMENTATION

Analog and digital signals, Block diagram of regulated DC power supply and its use in biasing the electronics circuits, Block diagram of digital multimeter and its uses in voltage, current and resistance measurements.

Block diagram of function generators (sine, square and triangular wave) and their characteristics, Block diagram of frequency counter and its working and uses, Block diagram of various cathode ray oscilloscopes and their uses in frequency, phase and voltage measurement

Origin of bio-electric signals associated with various organs, Electric cardio gram (ECG) and its application in heart functioning, Sonography (ultrasound imaging) and its application in diagnosis

Suggested Readings:

1. A. D. Helfrick and W. D. Cooper, Modern Electronic Instrumentation and Measurement Techniques,PHI.
2. R. S. Khandpur, Handbook of Biomedical Instrumentation, TMH.

ELECTRONICS INSTRUMENTATION PHYSICS LAB WORK

1. Measurements of voltage, current and resistance by DMM
2. Study of waves generation by function generator
3. Study of waves using CRO

4. Use of digital storage oscilloscope (DSO) in waveform study
5. Study of DC power supply
6. Study of function generator
7. Study of ultra sound generation and its application

ANUXURE- B2(2)

SYLLABUS OF MSc. II YEAR (III AND IV SEMESTERS)

SUBJECT: PHYSICS

(2019-2020)

MSc. Physics III Semester

Core Course 1

MSPH311: CLASSICAL ELECTRODYNAMICS

Unit I

Electrostatics: Poisson and Laplace equations, Green’s Theorem, Uniqueness of the solution with the Dirichlet or Neumann boundary conditions, Formal solutions of electrostatics boundary value problem with Green’s function, Electrostatics potential energy density.

Boundary value problems in Electrostatics: Method of images, Point charge in the presence of grounded conducting sphere, Point charge in the presence of a charge insulated conducting sphere, Point charge near a conducting sphere at fixed potential, Conducting sphere in uniform electric field by method of images.

Unit II

Maxwell Equations, Vector and scalar potentials, Gauge transformations, Lorentz gauge, Coulomb gauge, Green functions for wave Equation, Derivation of equations of macroscopic electromagnetism, Poynting theorem and conservation of energy and momentum for a system of charged particles, Poynting theorem in linear dispersive media with losses, Poynting theorem for harmonic field.

Unit III

Radiating Systems, Multipole Fields and Radiation: Fields and radiation of a localized oscillating source, Electric dipole fields and radiation, Magnetic dipole and electric quadrupole fields, Center fed linear antenna, Multipole expansion of the electromagnetic fields, Properties of multipole fields.

Collisions, Energy Loss and Scattering of Charged Particles: Energy transfer in a Coulomb collision between heavy incident particle and stationary free electron, Energy transfer to a harmonically bound charge, Thomson scattering, Cherenkov radiation.

Unit IV

Radiation by Moving Charges: Retarded time and retarded potential, Lienard–Wiechert potentials and fields for a moving point charge, Electromagnetic fields of a uniformly moving point charge, Total power radiated by an accelerated charge: Larmor's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary and extremely relativistic motion, Distribution in frequency and angle of energy radiated by accelerated charges.

Unit V

Dynamics of Relativistic Charged Particle: Lagrangian and Hamiltonian for a relativistic charged particle in external electromagnetic fields, Covariance of equation of motion, Euler-Lagrange equation, Motion of charged particle in uniform static magnetic field, Combined uniform static electric and magnetic fields, Motion of charged particle in non uniform static magnetic fields. Adiabatic invariance of flux through the orbit of particle.

Suggested Reading:

1. J.D. Jackson: *Classical Electrodynamics*, 2nd edition, John Wiley, 1985.
2. D.J. Griffith: *Introduction to Electrodynamics*, 3rd edition, Pearson Pub., New Delhi, 2003
3. Panofsky and Phillips: *Classical Electricity and Magnetism, 2nd edition*, Addison Wesley, 1962.
4. L.D. Landau and E.M. Lifshitz: *Classical Theory of Field, 4th edition*, Pergamon Press, 2003.
5. L.D. Landau and E.M. Lifshitz: *Electrodynamics of Continuous Media*, Pergamon Press, 1995.
6. J.R. Reitz, F.J. Milford R.W. Christry: *Foundation of Electromagnetic Theory*, 4th edition, Pearson Education, 2009.

MSc. Physics III Semester

Core Course 2

MSPH312: QUANTUM MECHANICS-II

Unit I

Theory of Scattering-I: The scattering experiments, Relationship of cross-section and wave function, Scattering amplitude; Partial wave analysis: Expansion of a plane wave in terms of partial waves, Scattering by central potential, Zero energy scattering; Scattering by a square well potential, Effective range, Resonant scattering.

Unit II

Theory of Scattering-II: Born approximation, Integral equation for scattering, Born's first approximation, Spherically symmetric potential, Criterion for validity of Born approximation, Scattering of electrons by atoms, Rutherford scattering.

Unit III

Identical Particles: Principle of indishtinguishability, Symmetry of wave functions, Spin and statistics, Pauli's exclusion principle, Construction of wave function of two electrons in L-S and j-j coupling, Allowed states, Ortho and para helium; Exchange force; Scattering of identical particles, Cases of spin half and spin zero particles.

Unit IV

Time Dependent Perturbation Theory: Constant perturbation, Transition to continuum, Fermi's golden rule, Harmonic perturbation, Radiative transitions; Adiabatic approximation, Sudden approximation.

Semi-Classical Theory of Radiation: Einstein coefficients, Atom field interaction, Interaction energy, Dipole matrix elements, Stimulated emission rate, Spontaneous emission rate, Selection rules.

Unit V

Relativistic Wave Equation: Klein Gordan equation, Dirac equation, Properties of Dirac matrices, Free Dirac particle, Equation of continuity, Non-relativistic limit, Spin-orbit coupling, Hole theory.

Suggested Reading:

1. J.J. Sakurai: *Modern Quantum Mechanics,* Addison Wesley, 2010.
2. V.K. Thankappan: *Quantum Mechanics, 2^{nd} edition,* New Age International (P) Limited, Publishers, New Delhi, 2010
3. A. Ghatak and S. Loknathan: *Quantum Mechanics: Theory and Application,* 4^{th} edition, Macmillan, 1999.
4. D.J. Griffith: *Introduction to Quantum Mechanics,2^{nd} edition,* Pearson Education, 2005
5. L.I. Schift: *Quantum Mechanics, 3^{rd} edition,* Mc-Graw Hill, 1968.
6. B.S. Rajput: *Advanced Quantum Mechanics,* Pragti Prakashan, Meerut, 1994.

MSc. Physics III Semester

Core Course 3

MSPH313: NUCLEAR PHYSICS-I

Unit I

General Properties of the Nucleus: Nuclear Size, Nuclear Spin, Parity of the Nuclei, Statistics of Nuclei, Magnetic dipole moment, Electric Quadrupole moment, Iso-spin, Size determination by Muonic X-ray Method and Life time of alpha emitters, Measurement of nuclear spin by Zeeman effect of hyperfine lines and by molecular spectra method, Magnetic dipole moment by Rabi's method.

Unit II

Nuclear Models: Introduction to nuclear models, Fermi gas model, Shell model of the nucleus: Harmonic potential, Spin-orbit interaction, Existence of shells, Application of shell model. Limitations of the shell models, Collective model: Rotational and vibration states, Nilson model and explanation of ground states of the nuclei.

Unit III

Energy Spectrum of α and β rays: Discrete energy spectrum of α particles, Geiger-Nuttal's law, Gammow theory of α decay, Continuous spectrum of β particles, Pauli's neutrino hypothesis, Fermi theory of β decay, Coulomb correction, Screening effect, Kurie's plot, Selection rules in β decay, Orbital electron capture, Parity violation in β decay.

Unit IV

γ –ray spectrum: γ –ray spectra and nuclear energy levels, Irradiative transition in nuclei, Nuclear isomerism, Internal conversion, Internal pair creation, Selection rules of γ–ray transitions.

Mössbauer Effect: Nuclear resonance, Recoil energy, Thermal broadening, Doppler broadening, Heisenberg, Natural line width, Recoil free fraction, Velocity modulation, Isomer shift, Quadrupole splitting, Magnetic Hyperfine splitting.

Unit V

Nuclear Accelerators: Particle accelerators: Linear accelerators, Cyclic accelerators, Fixed target machines and colliders, Synchrotron: Principle of phase stability, Synchrotron radiations.

Basic principles of particle detectors: G.M counter, Solid state and semiconductor detectors, Cherenkov counter, Scintillation Counters.

Suggested Reading:

1. K.S. Krane: *Introductory Nuclear Physics*, Wiley, New York. 1987,
2. D. Griffiths: *Introduction to Elementary Particle Physics*, Harper and Row, New York. 1987,
3. R.R. Roy and B.P. Nigam: *Nuclear Physics*, New Age International, New Delhi, 1983.
4. I. Kaplan: *Nuclear Physics*, 2^{nd} Edition, Narosa Pub. House, New Delhi, 1983.
5. H.A. Enge: *Introduction to Nuclear Physics*, Addison Wesley, London, 1975.
6. Y.R. Waghmare: *Introductory Nuclear Physics*, Oxford-IBH, New Delhi, 1981.
7. S. N. Ghoshal*: Atomic and Nuclear Physics*, Volume 2. , 2001.
8. J.M. Longo: *Elementary Particles*, Mc-Graw-Hill, New York, 1971.
9. R.D. Evans: *Atomic Nucleus*, Mc-Graw Hill, New York, 1955.
10. B.L. Cohen*: Concepts of Nuclear Physics*, TMH, New Delhi, 1971.
11. M.K. Pal: *Theory of Nuclear Structure*, Affl. East-West, Chennai, 1982.
12. W.E. Burcham and M. Jobes: *Nuclear and Particle Physics*, Addison-Wesley, Tokyo, 1995.

MSc. Physics III Semester

Elective core course- I

Group A: ELECTRONICS

MSPH314(A) : COMMUNICATION TECHNOLOGY

Unit I

Analog Communication: Modulation: Amplitude modulation-generation of AM waves, Demodulation of AM waves –DSBSC modulation, Generation of DSBSC waves, SSB modulation, Generation of SSB, Vestigial sideband modulation and frequency division multiplexing (FDM), Frequency modulation, Mathematical analysis, Generation of FM.

Demodulation: Demodulation of AM signals, Demodulation of FM signals: Foster Seeley discriminator, Ratio detector

Unit II

Digital Communication: Sampling theorem, PAM Channel BW for a PAM signal, Natural sampling. Flat top sampling, Pulse code modulation, Quantization and the binary code, Dynamic range, Coding efficiency, Quantization error, Noise in PCM signals, Companding,

Digital modulation techniques: ASK, FSK, BFSK, BPSK, QPSK,

Unit III

Transmission Lines: Voltage and current equations of transmission lines, Characteristic impedance, Propagation constant, Reflection coefficient, VSWR, Impedance transformation, Smith chart, Impedance matching by single stub and double stub.

Optical Fiber : Light propagation in fibers, Total internal reflection, Numerical aperture of a given fiber, Fiber index profiles, step index and graded index fiber, Modes of propagation, Number of propagated modes in step-index fibers.

Unit IV

Radars and Satellite: Radar System: Radar block diagram and operation, Radar frequencies, Pulse consideration radar range equation, Minimum detectable signal, Receiver noise, Signal to noise ratio, Integration of radar pulses, Radar cross section, Pulse repetition frequency, Pulsed radar system, Doppler's effect, CW Doppler Radar system, Moving target Indicator principle, FM radar.

Satellite Communication: Orbital satellites, Geo- stationery satellite, Orbital patterns, Look angles, Orbital spacing, Satellite systems link modules.

Unit V

Data Communication and Networking: Elements of LAN, WAN, MAN, Network topologies: STAR, BUS and RING network, Network Models: Layered tasks, OSI model, Layers in the OSI model, TCP/IP protocol suite, Switching: Concept of switching, circuit-switched networks, Datagram networks, Network switching, Addressing, Efficiency, Error Detection and Correcting Codes: Types of errors, Redundancy, Block coding, Hamming codes, Cyclic codes: Cyclic Redundancy Check, Hardware Implementation, Polynomials, Parity generation and detection,

Books Suggested:

1. Wayne Tomasi*: Introduction to Data Communication and Networking, 1^{st} Ed*., Pearson 2007.
2. Forouzan: *Data Communication and Networking, 4^{th} Ed*., TMH, 2006.
3. Roddy and Coolen: *Electronic Communication, 4^{th} Ed.*, PHI, 2004.
4. Anokh Singh: *Principles of Communication Engineering,* S. Chand & Company, 2^{nd} Ed. 2006.
5. Wayne Tomasi: *Advanced Electronic Communication System,* Pearson, 2009.

MSc. Physics (III Semester)

Elective Core Course-I

Group B: MATERIAL SCIENCE

MSPH314(B): MATERIAL SYNTHESIS AND CHARACTERIZATION

UNIT I

Introduction to Crystal Growth: Theories of crystal growth: Surface energy theory, Diffusion theory, Adsorption layer theory, Screw dislocation theory, Crystal growth techniques: Solid growth , Solution growth, Crystal growth from melt, Vapour phase growth.

UNIT II

Solid States and Solution Routes: Mechanical mixing, Grinding, Solid solution technique, Combustion method, Top seeded solution growth; Sol-gel techniques; Hydrothermal, Melt methods: Czechorlskii methods, Skull melting, Electro-chemical, Sono-chemical and Photo-chemical synthesis.

Unit III

X-ray, Electron and Neutron Diffraction Methods: XRD equipment, Powder method, Debye-Scherrer camera, Examination of typical XRD pattern, Crystal structure determination, Indexing XRD pattern, Scherrer formula for estimation of particle size, Lattice parameters calculations and other uses, Electron diffraction and its uses.

Unit IV

Basics of Thermal Analysis Techniques: TGA, DTA, DSC principles and applications.
Electron Imaging Techniques and their Applications: Principle and working of SEM, TEM, AFM.

Unit V

Spectroscopic Techniques: Mass spectroscopy, Principle and applications, Secondary ions mass spectroscopy, Special surface techniques: Electron spectroscopy for chemical analysis (ESCA), Ultraviolet photo electron spectroscopy (UPS), X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES).

Suggested Reading:

1. Ichiro Sunagawa: *Crystals: Growth, Morphology and Perfection*, Cambridge University Press, Cambridge, 2005.
2. J. W. Mullin: *Crystallization*, Elsevier Butterworth-Heinemann, London, 2004.
3. J. C. Brice: *Crystal Growth Processes*, John Wiley and Sons, New York, 1986.
4. H. H. Willard*: Instrumental methods of Analysis*, CBS Publishers, 1986.
5. B. D. Cullity: *Elements of X-ray Diffraction*, Addison Wesley Publishing Co., 1967.
6. Sam Zhang, Lin Li and Ashok Kumar: *Materials Characterization Techniques*, CRC Press, 2008.
7. Yang Leng: *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, Wiley & Sons, 2008.
8. Elton N. Kaufmann: *Characterization of Materials, Vol.1*, Wiley & Sons, 2003.
9. R.A. Laudise: *Growth of Single Crystals*, Prentice Hall, 1973.
10. G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), *Springer Handbook of Crystal Growth,* Springer Verlag, 2010.

MSc. Physics (III Semester)

Core Course 5

MSPH311: GENERAL PHYSICS LAB

List of Experiments:

1. To determine and compare slit width from the study of Fraunhoffer Diffraction pattern.
2. To measure Brewster angle and hence to find the refractive index of given material.
3. To determine basic laser beam parameters of a given laser.
4. To study Magneto- Optic effect and hence to determine Verdet constant of a given material.
5. To study Electro- Optic effect and to determine the value of half wave voltage.
6. To study the Special Coherence using laser beam with double slit.
7. To Study the dissociation spectrum of Iodine.
8. Study of Balmer lines in Hydrogen atom.

MSc. Physics (III Semester)

Core Course 6

MSPH322: NUCLEAR PHYSICS LAB.

List of Experiments:

1. To study of the characteristics of a GM tube and determination of its operating voltage, Plateau length and Slope.
2. Verification of inverse square law for gamma rays.
3. Study of nuclear statistics.
4. Linear and mass attenuation co-efficient using gamma/beta ray source.
5. Estimation of efficiency of G.M. detector for gamma and beta ray source.
6. Study of energy resolution characteristics of a scintillation spectrometer as a function of applied high voltage and to determine the best operating voltage.
7. Study of Cs-137 spectrum and calculation of FWHM and resolution for a given scintillation detector.
8. Study of Co-60 spectrum and calculation of resolution of detector in terms of energy.
9. Energy calibration of gamma ray spectrometer (study of linearity).
10. Calculation of unknown energy of a radioactive isotope.
11. Variation of energy resolution with gamma energy.

MSc. (III Semester)

Skill Course –III(A)

MSPHSC333(A) : RENEWABLE ENERGY RESOURSES

Introduction to Renewable Energy Systems: Need for renewable energy sources, Different types of renewable energy sources, Advantages and limitations of renewable energy sources (non-conventional energy sources).

Sun as a source of energy, Solar radiation fundamentals, Estimation of radiation, Measurement of solar radiation, Direct energy conversion (Solar Photovoltaic): Semiconductors , Photoconduction, Solar cell fundamentals, Solar cell structure, Solar cell characteristics, I-V characteristics, Tracking-maximum power point tracking. Energy loss and efficiency, Maximizing the performance, Classification of solar cell, Solar cell fabrication technology, Solar cell PV module, PV panel, Testing of PV system, Array Construction, Small grid technology, Solar PV applications.

Wind Energy and Other Renewable Energy Sources: Power in the wind, Wind measurement techniques and instrumentation, Wind energy conversion, Wind mill, Basic components of wind mill conversion system, Types of wind mills, Performance and efficiency.

Suggested Readings:

1. B. H. Khan, Non-Conventional Energy Resources, The McGraw Hill, 2001.
2. G. D. Ray, Non-Conventional Energy Sources, Khanna Publications, 2001.
3. S.P. Sukhatme, Solar Energy, Mc Graw Hill, 1997.
4. S. P. Sukhatme and J.K. Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw-Hill, New Delhi, 1989.
5. Garg, Prakash, Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 1993.
6. C.S. Solanki, Solar Photovoltaics: Fundamental, Technologies and Applications, Prentice Hall of India, 2011.
7. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, Chichester, 1984.
8. John Twidell and Tony Weir, Renewable Energy Resources, 2nd edition, Fspon & Co., 1990.
9. Solar Energy, Fundamentals and Applications, Garg, Prakash, Tata McGraw Hill
10. Erich Hau, Wind Turbines Fundamentals: Technologies, Application, Economics, Springer Verlag Berlin, Heidelbeg, 2000.
11. Gary L. Johnson, Wind Energy System, Printice Hall Inc, New Jersy, 1985.
12. S.N. Bhadra, D. Kastha and S. Banerjee, Wind Electrical Systems, Oxford Univ Press 2005.

RENEWABLE ENERGY RESOURSES LAB WORK

1. Study of the voltage and current of the solar cells in series and parallel combinations.
2. Study of the voltage and current of the solar cells.
3. Study of both the current–voltage characteristic and the power curve to find the maximum power point (MPP) and efficiency of a solar cell.
4. To calculate the efficiency (η) of solar cell.
5. Measurement of voltage and current of wind energy based DC supply with change in angle of blades.
6. Measurement of voltage and current of wind energy based DC supply with change in direction of wind.
7. Measurement of voltage and current of wind energy based DC supply with change in speed of wind imposed on the blades.

MSc. (III Semester)

Skill Course –III(B)

MSPHSC333(B): INTRODUCTION TO PROGRAMMING IN C-LANGUAGE AND COMPUTER SIMULATION IN PHYSICS

C Language Preliminaries: C character set, Identifiers and keywords, Data types, Declarations, Expressions, Statements and symbolic constants, Input-Output: getchar, putchar, scanf, printf, gets, puts, functions.

Pre-processor Commands: #include, #define, #ifdef, Operators and Expressions: Arithmetic, Unary, Logical, Bit-wise, Assignment and conditional operators, Control Statements: While, Do-While, For statements, Nested loops, If else, Switch, Break, Continue and goto statements, Comma operators.

Functions: Defining and accessing, Passing arguments, Function prototypes, Recursion, Library functions, Static functions Arrays: Defining and processing, Passing arrays to a function, Multi dimensional arrays, Strings and pointers, operations on strings and pointers.

Introduction to Computer Simulation: The importance of computer simulation, Programming languages and object oriented techniques, Tools for simulations, Simulation of particle motion in one dimensions.

Simulation in wave, optics and electromagnetic: Simulation of a plane wave, Dispersion of light waves, Electric field due to a point charge, Motion of charge particle in uniform magnetic field.

Suggested Readings:

1. H. Gould, J.Tobochnik and W. Christian, An Introduction to Computer Simulation Method, Pearson, New York, 1953.
2. R.C. Verma, Computer Simulation in Physics, Anamaya Publisher, New Delhi, 2004.
3. K.R. Venugopal and S.R. Prasad: *Mastering C*, TMH, Delhi, 2006.
4. E. Balagurusamy: *C–Programming,* Tata Mc-Graw Hill, 2006.

INTRODUCTION TO PROGRAMMING IN C-LANGUAGE AND COMPUTER SIMULATION IN PHYSICS LAB WORK

1. Simulation of one dimensional simple harmonic motion.
2. Simulation of construction of a standing wave.
3. Simulation of interference of two waves.
4. Simulation of motion of electron in cathode ray tube.
5. Simulation of motion of electron in combined electric and magnetic field.

MSc. Physics (IV Semester)

Core Course 1

MSPH411: NUCLEAR PHYSICS-II

Unit I

Nuclear Forces: Two body problem, Ground state of deuteron, Magnetic moment, Quadruple moment, Tensor forces, Meson theory of nuclear forces, Yukawa potential, Nucleon-nucleon scattering, Low energy n-p scattering, Effective range theory, Spin dependence, Charge independence and charge symmetry of nuclear forces.

Unit II

Nuclear Reactions: Energetic of nuclear reactions, Reaction dynamics, Q-value equation, Scattering and reaction cross sections, Compound nucleus, Reciprocity theorem, Breit-Wigner one level formula, Resonance Scattering, Continuum theory, Optical model.

Unit III

Neutron Physics and Reactor Physics: Neutron production, Slowing down power and moderating ratio, Neutron detection, Mass and energy distribution of nuclear fragments, Four factor formula, Reactor operations, Power and breeder type reactors.

Nuclear Fusion: Introduction, Thermonuclear reactions and energy production, Fusion in hot medium, Progress in fusion power production, Stellar burning.

Unit IV

Basic interaction of various particles with matter: Interaction of Charge particles with matter; Bohr-Bethe formula, Interaction of electrons, Interaction of γ–rays with matter: Photo electric, Compton effects and pair production.

Unit V

Particle Physics: Classifications of elementary particles, Isospin, Isospin quantum numbers, Strangeness and hyper charge, Hadrons, Baryons, Leptons, Invariance principles and symmetries, Invariance under charge-parity(CP), time(T) and CPT, CP violation in neutral K-meson decay, Tau-Theta puzzle, Feynman diagrams, Quark model, SU(3) symmetry, Gell-Mann-Nishijma formula, Neutrinos of different flavour, Charm, Bottom and Top quarks, QCD formulated, Evidence for gluon field.

Suggested Reading:

1. K.S. Krane: *Introductory Nuclear Physics*, Wiley, New York. 1987.
2. D. Griffiths: *Introduction to Elementary Particle Physics*, Harper and Row, New York. 1987.
3. R.R. Roy and B.P. Nigam: *Nuclear Physics*, New Age International, New Delhi, 1983.
4. I. Kaplan: *Nuclear Physics*, 2nd Edition, Narosa, New Delhi, 1983.
5. J.S.Lilley, John Wiley & Sons Ltd., UK, 2001.
6. S. N. Ghoshal*: Atomic and Nuclear Physics*, Volume 2. , 2001.

7. R.D. Evans: *Atomic Nucleus*, Mc-Graw Hill, New York, 1955.
8. B.L. Cohen*: Concepts of Nuclear Physics*, TMH, New Delhi, 1971.
9. M.K. Pal: *Theory of Nuclear Structure*, Affl. East-West, Chennai, 1982.
10. W.E. Burcham and M. Jobes: *Nuclear and Particle Physics*, Addison Wesley, Tokyo, 1995.

MSc. Physics (IV Semester)

Core Course 2

MSPH412: ATOMIC AND MOLECULAR SPECTROSCOPY

Unit I

Atomic Spectroscopy: General discussion in Hydrogen spectra, Relativistic correction to spectra of Hydrogen atom, Spectra of monovalent atoms, quantum defect, Introduction to electron spin, Spin-orbit interaction and fine structure, Spectra of divalent atoms: Singlet and triplet states of divalent atoms, L-S and j-j coupling, Branching rule, Hyperfine structure in spectra of monovalent atoms.

Unit II

Microwave Spectroscopy: Pure rotational spectra of diatomic molecules, Isotopic effect, Non-rigid rotator, Poly-atomic molecules, Study of linear molecules and symmetric top molecules, Stark effect, Quadrupole hyperfine interaction, Microwave spectrometer, Information from rotational spectra.

Unit III

Infrared Spectroscopy: Vibrational spectroscopy of diatomic and simple polyatomic molecules, Harmonic Oscillator, Anharmonic Oscillator, Rotational vibrators, Normal modes of vibration of polyatomic molecules, IR spectrometer: FTIR Spectrometer, Applications of infrared spectroscopy: H_2O and CO_2 molecules.

Unit IV

Raman Spectroscopy: Raman effect, Classical and Quantum theory of Raman effect, Vibrational Raman spectra, Rotational Raman spectra, Vibrational-Rotational fine structure, Raman Spectrometer, Structure determinations from Raman and Infra-red spectroscopy.

Electronic Spectra: Electronic structure of diatomic molecules, Intensity of spectral lines, Frank-Condon principle, Dissociation energy and dissociation products, Rotational fine structure of electronic-vibration transitions.

Unit V

NMR and ESR Techniques: Theory of NMR, Relaxation effect, Theory of dipolar interaction and chemical shifts, Indirect spin-spin interactions, Experimental set up of NMR, Applications of NMR to quantitative measurements (Idea only).

ESR: Quantum mechanical treatment of ESR, Nuclear interaction and hyperfine structure, Relaxation effects, ESR spectrometer, Applications of ESR method.

Suggested Reading:

1. Willard, Merritt, Dean, Settle: *Instrumental Methods of Analysis*, CBS Publishers & Distributors, Delhi, 6^{th} Ed. 1986.
2. Colin N. Banwell and Elaine M. McCash*: Molecular Spectroscopy*, Mc-Graw Hill College; 4^{th} Sub. Ed., 1994.
3. B. H. Bransden and Joachain: *Physics of Atoms and Molecules*, Longman, 1983.
4. V. Rajendran and A. Marikani: *Applied Physics*, TMH publication, 4^{th} Ed., 2002.

5. P. F. Bernath: *Spectra of Atoms and Molecules*, Oxford University Press, 1995.
6. Raymond Chang: *Basic Principles of Spectroscopy*, Mc-Graw Hill, 1971.
7. P. W. Atkins: *Molecular Quantum Mechanics*, Oxford University Press, 1983.
8. B. B. Laud: *Lasers and Non-Linear Optics*, Wiley Eastern Ltd., 1991.
9. H. E. White: *Introduction to Atomic Spectra*, Tata Mc-Graw Hill. 1934.
10. G. Herzberg: *Molecular Spectra and Molecular Structure* Vol. 1, 2 & 3, Krieger Publishing Company, Malabar, 1989 & 1991.
11. D. A. Long: *Raman Spectroscopy*, Mc-Graw Hill, 1977.
12. G. M. Barrow: *Introduction to Molecular Spectroscopy*, Mc-Graw Hill, Tokyo, 1962.
13. J. M. Brown: *Molecular Spectroscopy*, Oxford University Primer, 1998.
14. J. M. Holias: *Modern Spectroscopy*, John Wiley & Sons, England, 1987.

MSc. Physics (IV Semester)

Core Course 3

MSPH413: NANOMATERIALS

Unit I

Introduction: Nano size scale, History of Nanotechnology, Quantum Mechanics and Fluctuation in nanostructure systems, Surface area to volume ratio, Surface energy, chemical potential as a function of surface curvature, Electrostatic stabilization and Steric stabilization, Idea of zero, one and two dimension nanostructures, Vacancies and dislocations in nanocrystals, Effect of nanoscale dimensions on various properties.

Unit II

Structure and Phase Transitions in Nanocrystals: Introduction, Crystalline phase transitions in nanocrystals: Phase transitions and grain size dependence, Elementary thermodynamics of the grain size dependence of phase transitions, Influence of the surface or interface on nanocrystals, Modification of transition barriers, Geometric evolution of the lattice in nanocrystals: Grain size dependence theory, Influence of the nanocrystal surface or interface on the lattice parameter, Continuous variation of the crystal state within nanocrystals .

Unit III

Synthesis of Nanomaterials: Physical methods: High energy ball milling, Melt mixing, Lithography: Photolithography, Electron beam lithography, X-ray lithography, Chemical methods: Colloidal and sol-gel methods, Other methods: Methods for templating the growth of nanomaterials, Self-assembly method, Bio-induced nanomaterials (using microorganism and plant extract).

Unit IV

Physical Properties of Nanomaterials: Melting point and lattice constants, Mechanical properties, Optical properties; Surface Plasmon effect, Quantum size effect, Electrical conductivity; Surface Scattering, Change of Electronic structure, Quantum Transport, Effect of microstructure, Ferroelectric and dielectrics, Superparamagnetism.

Unit V

Applications of Nanomaterials: Application in molecular and nano-electronics, Biological applications (imaging, drug delivery), Quantum well and quantum dot devices, Energy application of nanomaterials; Photochemical cell, Lithuim –ion battery, Hydrogen storage and thermo-electrics, Environmental application, Photonic crystals.

Suggested Reading:

1. Guozhong Cao and Ying Wang: *Nanostructures and Nanomaterials: Synthesis, Properties and Applications, 2nd Ed.*, World Scientific, Singapore, 2011.
2. S.M. Lindsay: *Introduction to Nanoscience*, Oxford University Press, New York, 2010.
3. B.K. Parthasarthy (Edited): *Nanoscience and Nanotechnology*, Isha Books, Delhi, 2007.
4. Mark Ratner and Daniel Ratner*:* *Nanotechnology: A Gentle Introduction to Next Big Idea*, Pearson Education, 2008.
5. Gregory Timp (Edited): *Nanotechnology*, Springer, New York, 1999.
6. Charles P. Poole Jr. and Frank J. Owens*:* *Introduction to Nanotechnology*, Wiley Interscience, 2003.

7. Catherine Brechignac, Philippe Houdy and Marcel Lahmani, Spinger Berlin Heidelberg: *Nanomaterials and Nanochemistry*, New York, 2006.
8. Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan (Edited): *Nanoscale Science and Technology*, John Wilet & Sons Limited, England, 2005.
9. Yury Gogotsi (Edited): *Nanomaterials Handbook*, CRC, Taylor & Francis, New York, 2006.

MSc. Physics (IV Semester)

Core Elective Course-II

Group A: ELECTRONICS

MSPH414(A): NETWORK ANALYSIS AND MICROWAVE ELECTRONICS

Unit I

Network Analysis and Laplace Transform Method: Analysis of simple L, C, R –circuits by solving differential equations, Laplace transform method, transient and steady state AC response; Transform functions of step, Delayed step, Rectangular pulse, Impulse and ramp; Application to simple circuits.

Unit II

S-Plane Analysis: Transform impedance and admittance functions, Thevenin and Norton theorems, Two port networks, Driving point impedance, Transfer functions, Poles and zeros of network functions, Restrictions on poles and zeros of driving point impedance and transfer functions, Time domain response from pole zero configuration.

Frequency Response Plots: Magnitude and phase plots, Complex loci, Plots from s-plane phasors, Bode plots.

Unit III

Introduction: Microwave frequency bands; Limitations of conventional devices at microwave frequencies.

Wave Guides: Wave propagation between parallel planes, Modes of propagation, Rectangular and circular wave guides, Impedance concept in wave guide, Impedance measurement by VSWR, Measurement of dielectric constant at microwave frequency, Cavity resonator, Measurement of frequency.

Unit IV

Microwave Components: Scattering matrix, Phase shifters, Directional couplers; E-plane, H-plane and Hybrid Tees; Ferrite isolators, Circulator.

Microwave Tubes: Velocity modulation, Basic principles and characteristics of two cavity klystron and reflex klystron; Magnetrons; Slow wave structure, Helix travelling wave tube, Wave modes, Gain.

Unit V

Semiconductor microwave devices: Microwave tunnel diodes; HEMT; Transfer electron devices, Gunn effect, Principle and modes of operation; Read diode, IMPATT and TRAPATT; Varactor, Parametric converters, Manley Rowe relations, Up converter and negative resistance amplifier.

Suggested Reading:

1. S.Y. Liao: *Microwave Devices and Circuits,3rd Ed.*, Prentice Hall of India, 1992.
2. G. Kennedy: *Electronic Communication Systems*, Tata Mc-Graw Hill, 1991.
3. R.E. Collins: *Foundations of Microwave Engineering*, Mc-Graw Hill, 1981.
4. E. Jordan and K.G. Balmain*: Electromagnetic Waves and Radiating System*, Prentice Hall of India, 1968.
5. F.E. Terman*: Electronic and Radio Engineering 4th Ed..*, Mc-Graw Hill, 1957.
6. G.S. Raghuvanshi*: Microwave Engineering*, CL India, 2012.

MSc. Physics (IV Semester)

Core Elective Course -II

Group B: MATERIAL SCIENCE

MSPH414(B): THIN FILMS

Unit I

Preparation of Thin Films: Study of thin film vacuum coating unit, Construction and uses of vapor sources wire, Sublimation Furnaces and Crucible sources.

Physical Vapor Deposition: Hertz Knudsen equation, Mass evaporation rate, Knudsen cell, Evaporation of elements, Compounds, Alloys, Raoult's law, Electron beam, Pulsed laser, Ion beam evaporation, Glow Discharge and plasma.

Unit II

Sputtering: Sputtering mechanisms and yield, DC and RF sputtering, Magnetron sputtering, Bias sputtering, Reactive sputtering, Evaporation versus Sputtering, Hybrid and modified PVD processes-Ion plating, Reactive Evaporation, Ion beam assisted deposition.

Unit III

Chemical Vapor Deposition: Thermodynamics of CVD, Gas transport, Film growth kinetics, Thermal CVD, LPCVD, MOCVD, laser and Plasma-enhanced CVD processes.

Chemical Methods: Qualitative study of preparation of thin films by electroplating, Anodization, Spray pyrolysis, Electro-deposition, Sol-Gel and LB techniques.

Unit IV

Nucleation and Growth: Homo, heterogeneous nucleation, Capillarity theory, Nucleation rate, Atomistic and kinetic models of nucleation, Basic modes of thin film growth, Amorphous thin films.

Epitaxy: Homo, Hetero epitaxy, Lattice misfit and imperfections in epitaxial films, Epitaxy of compound semiconductors, Methods for depositing Epitaxial semiconductor thin films.

Unit V

Deposition Monitoring and Control: Microbalance, Crystal oscillator thickness monitor, Thickness measurement: Fringes of equal thickness (FET) method-Multiple beam interferometer, Fringes of equal chromatic order (FECO) method-Ellipsometry.

Scope of Devices and Applications: Thin film resistors, Thin film capacitors, Thin film field effect transistors, Thin film solar cells, Antireflection coatings.

Books Suggested:

1. Milton Ohring: The *Materials Science of Thin Films,* Academic Press, California 1992.
2. K. L Chopra: *Thin Film Phenomena,* Krigger publishing company, Huntington, New York 1979.

3. L.I. Maissel and R. Glange: *Hand Book of Thin Film Technology*, Mc-Graw Hill, New York, 1970.

4. Donald Smith: *Thin-Film Deposition: Principles and Practice*, Mc-Graw Hill**,** 1st Ed., 1995.

MSc. Physics (IV Semester)

Core Elective Lab-I

Group A: ELECTRONICS

MSPH421(A): ELECTIVE PAPER LAB

List of Experiments:

1. Characteristics of Reflex Klystron
2. Measurement of VSWR and impedance
3. Measurement of dielectric constant
4. Amplitude modulation and demodulation
5. Pulse amplitude modulation and demodulation
6. Optical fiber communication
7. A/D conversion
8. D/A Conversion
9. Pulse width modulation and demodulation

MSc. Physics (IV Semester)

Core Elective Lab-I

Group B: MATERIAL SCIENCE

MSPH421(B): ELECTIVE PAPER LAB

List of Experiments:

1. Experiments with introductory Nano Kit.(Understanding nano scaling and demonstrating atomic arrangement).
2. Experiments based on Nano TiO_2 Solar Cell Trainer Kit.(Four experiments).
3. Experiments based on ferro-fluid demonstrator. (Three experiments).
4. Measurement of dielectric constants at microwave frequency.
5. Experiments with lattice dynamics kit.
6. Study of electron spin resonance in a paramagnetic crystal and calculation of Lange-g-factor.
7. Study of Curie temperature in a ferroelectric crystal and determination of dielectric constant.
8. Measurements of various magnetic parameters using hysteresis loop tracer.
9. Measurement of dielectric constant of a liquid/film using LCRQ meter.
10. Study of Hall effect in semiconductor crystals.

MSc. Physics (IV Semester)

Core Course 6

MSPH422: PROJECT

All the students have to carry out a project. The project work may be experimental or theoretical. Each student has to carry out his individual project. At the end of the semester each student has to submit a report of the work. The assessment of the project work will be done by the presentation of the work by the students.

MSc. (IV Semester)

Skill Course –IV

MSPHSC434: BASICS OF NANOSCIENCE

Introduction to Nanoscience: The nanoscale, History of Nanoscience and Technology, Differences between micro and nano type materials, Quantum confinement, Size dependent properties, Surface to volume ratio, Classification of nanomaterials.

Synthesis of Nanomaterials: Bottom-Up and Top-Down approach with examples, Sol-gel method, Mechanical-ball milling, Colloidal synthesis and capping of nanoparticles, biological synthesis, Characterization techniques: SEM, TEM, XRD.

Properties of Nanomaterials: Mechanical, Electrical, Thermal, Optical, Magnetic, Melting point, Application of Nanomaterials: Chemical, Environmental, Information and Communication, Nanoelectronics, Nano biotechnology, Drug delivery system.

Suggested Readings:

1. Nanotechnology: Principles and practices, S. K Kulkarni, Capital Publ. Co., New Delhi (2007).
2. Nanomaterials, A.K. Bandyopadhyay, New Age International Publications, 2009.
3. Nanomaterials: Synthesis, Properties and Applications, A.S. Edelstein and R.C. Cammearata, eds., Institute of Physics Publishing, Bristol and Philadelphia, 1996.
4. Nanoscale charecterisation of surfaces & Interfaces, N John Dinardo, Weinheim Cambridge, Wiley-VCH, 2000.
5. Guozhong Cao and Ying Wang: *Nanostructures and Nanomaterials: Synthesis, Properties and Applications, 2nd Ed.*, World Scientific, Singapore, 2011.

BASICS OF NANOSCIENCE LAB WORK

1. Experiments with introductory Nano Kit.(Understanding nano scaling and demonstrating atomic arrangement).
   (Two Experiments)
2. Experiments based on Nano TiO_2 Solar Cell Trainer Kit
   (Four experiments)
3. Experiments based on ferro-fluid demonstrator.
   (Three experiments)
4. Some simple experiments on synthesis of few nanomaterials.