

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 last week of November/ first week of December and even semester University examination shall be during first/ second week of May. 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
 45 to 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

$$\text{SGPA (Si)} = \frac{\sum(C_i \times G_i)}{\sum C_i}$$

where C_i is the number of credits of the i th course and G_i is the grade point scored by the student in the i th 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.

$$\text{CGPA} = \frac{\sum(C_i \times S_i)}{\sum C_i}$$

where S_i is the SGPA of the i th semester and C_i 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, $CGPA = \frac{24 \times 7.00 + 24 \times 6.58 + 24 \times 6.65 + 24 \times 6.89}{96} = 6.78$

- 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

COURSE TYPE	COURSE 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

COURSE TYPE	COURSE 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	MSPHSC23 2	ELECTRONICS INSTRUMENTATION	2-0-2	-	-	-	-
TOTAL				24	180	420	600

\$ Lectures/Tutorials/Practical per week

Continuous Comprehensive Assessment

* End Semester Examinations

SEMESTER III

COURSE TYPE	COURSE 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	MSPHSC33 3 (A/B)!!	(A). RENEWABLE ENERGY RESOURCES (B). INTRODUCTION TO 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

COURSE TYPE	COURSE 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	MSPHSC43 4	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

MSC PHYSICS I SEMESTER

COURSE TYPE	COURSE 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

CORE COURSE 1 : MSPH 111: CLASSICAL MECHANICS

UNIT - 1	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 - 2	Hamiltonian dynamics: Hamiltonian function H and conservation of energy: Jacobi's integral and its significance, Hamilton's equation, Routhian. Hamilton's 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 - 3	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. Kepler's Problems: Equation of orbit and the kind of the orbit, Motion in time
UNIT - 4	The kinematics of rigid body motion: Independent co-ordinate of a rigid body, Orthogonal transformation, Formal properties of transformation matrix, Euler angles, Euler'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 - 5	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

CORE COURSE 2: MSPH 112: MATHEMATICAL PHYSICS

UNIT - 1	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
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UNIT - 2	Fourier and Laplace Transforms: Fourier transform, Convolution theorem, Laplace transforms, Laplace transform of derivatives, Substitution properties of Laplace transform, Properties of gamma function, Dirac delta functions
UNIT - 3	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 - 4	Coordinates Transformation in N- dimensional Space: Covariant & contra-variant vectors and tensors; associate tensors, algebra of tensors, symmetric & anti-symmetric tensors, metric tensor, Christoffel's symbol & their transformation laws, Gradient, Divergence and Curl and tensor form Elementary Group Theory: Definition of a group, Homomorphism, Isomorphism, rotation groups SO(2) and SO(3)
UNIT - 5	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

CORE COURSE 3: MSPH 113: COMPUTATIONAL PHYSICS	
UNIT - 1	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 - 2	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
UNIT - 3	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: Defining and operations on strings. Pointers: Declarations, Passing pointers to a function, Operations on pointers, Pointer arithmetic, Pointers and arrays, Arrays of pointers, Function pointers
UNIT - 4	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. Numerical Differentiation: Forward difference and central difference methods, Differentiations of tabulated functions
UNIT - 5	Numerical Integrations: Newton-Cotes method, Trapezoidal rule, Simpson's 1/3 and 3/8 rules, Gauss-Quadrature Method, Error estimates, Monte Carlo method of numerical Integration. Solution of Ordinary Differentials Equations: Euler and Runga-Kutta Methods, Predictor-corrector method. Curve Fitting: Interpolation, Polynomial forms, Linear interpolation, Interpolation with equidistance points, Regression, Fitting of linear equation, Least square regression, Fitting transcendental equation

SUGGESTED READINGS

1. E. Balagurusamy: *Numerical Methods*, TMH, New Delhi, 2006
2. Suresh Chandra: *Computer Application in Physics with FORTRAN, BASIC and C, 2nd edition*. 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 Programming 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.
7. K.R. Venugopal and S.R. Prasad: *Mastering C*, TMH, Delhi, 2006.
8. E. Balagurusamy: *C-Programming*, Tata Mc-Graw Hill, 2006.
9. R.G. Dromey: *How to solve it by Computer*, Pearson Education India, 2008.
10. B.S. Gottfried: *Schaums Outline of Theory and Problems of Programming with C*: Mc-Graw Hill, 1993.
11. B.W. Kernighan and D.M. Ritchie: *C Programming Language*: Prentice Hall, 1988.
12. Ram Kumar and Rakesh Agarwal: *Programming in ANSI C*, West Pub. Co., 1992.
13. Y.P. Kanetkar: *Let Us C*, Infinity Science Press, LCC, 2008

CORE COURSE 4: MSPH 114: SEMICONDUCTOR DEVICES AND CIRCUITS

UNIT - 1	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 - 2	Bipolar Junction Devices: Bipolar junction transistor, I-V characteristics, Switching action, Thyristors and UJT. Metal semiconductor devices and FETs, Metal semiconductors barrier, Schottky effect, Energy band and I-V characteristics, MOSFET, LED: materials, Configurations and efficiency
UNIT - 3	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 - 4	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 - 5	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 READINGS

1. S.M. Sze: *Physics of Semiconductor Devices*, 2nd edition, Wiley India, 2004.
2. Ramkant A. Gayakwad: *Op-Amps and Linear Integrated Circuits*, PHI, New Delhi, 4th 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, 2nd Ed., 1993.
6. S.M. Zee: *Semiconductor Devices: Physics and Technology*, 2nd Ed., Wiley India, 2002.
7. Allen Mottershed: *Electronic Devices and Circuits*, PHI, 2005

CORE COURSE 5 : MSPH121: COMPUTATIONAL PHYSICS LAB

List of Experiments:

(Use C Language in this lab)

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

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

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

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, Fiber 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

BSPH121: PHYSICS LAB
<ol style="list-style-type: none">10. Study of bending of a beam and determination of Young's modulus.11. Modulus of rigidity by Statical method (Horizontal method).12. Modulus of rigidity by Statical method (Barton method)13. Modulus of rigidity by Dynamical method (Maxwell's needle).14. Elastic constants by Searle's method.15. To determine the Poisson's ratio of a rubber tube.16. Determination of surface tension of water by Jaegger's method.17. Variation of magnetic field along the axis of circular coil.18. Study of phase relations in CR circuit.19. Study of phase relations in LCR circuit.20. Study of Faraday's Law

SUGGESTED READINGS
<ol style="list-style-type: none">1. M.G. Bhatawedekar, S.S. Choudhry and T.L. Dashora: <i>University Physics Practicals</i>, Ramesh Book Depot, Jaipur, 1987.2. K.C. Bhandhari, <i>Practical Physics</i> (Hindi): Himanshu Publication, Udaipur, 2004.3. S.L. Gupta and V. Kumar: <i>Practical Physics</i> (Hindi & English), Pragti Prakashan, Meerut, 1998.4. Patitapaban Mishra and Jyotis Chandra Mohanti : <i>Advanced Physics Laboratory Manual</i>, South Ashian Publishers Pvt. Ltd., New Delhi, 2007

MSC PHYSICS II SEMESTER

COURSE TYPE	COURSE 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

CORE COURSE 1 : MSPH211: DIGITAL ELECTRONICS AND MICROPROCESSOR

UNIT - 1	Digital Circuits: Logic gates, De-Morgans theorems, Universal Gates, Karnaugh Maps. Various logic families: Transistor as a switch, Fan-in and Fan-out, Propagation delay, RTL, DTL, TTL, NMOS, CMOS
UNIT - 2	Flipflops, RS flipflop, D flipflop, JK flipflop, Edge triggered, Preset and Clear. Counters and Registers: Asynchronous counters, up-down counter, Synchronous counter, MOD counters, Range counters, Registers, Shift registers, Parallel loading, Universal shift registers
UNIT - 3	Micro-Computer Hardware: Buses: Data, Address and control buses, CPU: Instruction register and decoder, ALU, Control unit, Minimum microcomputer configuration, Interrupts, Maskable and non-maskable interrupts, Call Locations, Interrupt service subroutine, Vectored and non-vectored interrupts, Priority of interrupts, Concept of I/O mapped and memory mapped I/O
UNIT - 4	8085 Microprocessor: Microprocessor 8085: Organization of 8085 microprocessor, Fetch and execution of instruction, Bus multiplexing, 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, register, and implicit, Assembly language programming
UNIT - 5	Data Transfer, Peripheral devices and Interfacing: Types of data transfer, Direct Memory Access, 8257 DMA controller, I/O ports, 8255 programmable peripheral interface, 8279 keyboard-display interface, Digital to analog convertor(D/A) : weighted resistor and ladder method, Analog to digital convertor(A/D) : successive approximation method, Counter type method

SUGGESTED READINGS

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

CORE COURSE 2 : MSPH212: QUANTUM MECHANICS-I

UNIT - 1	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, Hermitian operator, Eigen value and eigen function, Representation theory, Change of basis, Unitary operator, Matrix elements, Unitary transformation, Diagonalization, Coordinate and momentum representation
UNIT - 2	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 - 3	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 annihilation 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 - 4	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 - 5	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, Time independent perturbation theory: Non degenerate case, Application to anharmonic oscillator (X^4) and linear harmonic oscillator

SUGGESTED READINGS

1. A 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. Schiff: *Quantum Mechanics, 3rd edition*, Mc-Graw Hill, 1968.
1. B.S. Rajput: *Advanced Quantum Mechanics*, Pragti Prakashan, Meerut, 1994

CORE COURSE 3 : MSPH213: SOLID STATE PHYSICS

UNIT - 1	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 - 2	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 - 3	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 tunnelling, dc and ac Josephson Effect, SQUID, High temperature superconductors
UNIT - 4	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 - 5	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 READINGS

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. Ashcroft N.D. Mermin: *Solid State Physics*, Holt, Rinehart and Winston, 1976.
5. A.J. Dekker: *Solid State Physics*, Prentice Hall, 1957

CORE COURSE 4 : MSPH214: STATISTICAL AND PLASMA PHYSICS

UNIT - 1	Ensembles Theory and Boson gas: Micro canonical, Canonical and grand canonical ensembles, Phase spacing of classical system, Liouville's 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 - 2	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, Landau diamagnetism, Ultra cold Fermi gas, White dwarf stars, Nuclear matter, Statistical model of an atom
UNIT - 3	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 Magnetosphere 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 - 4	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 - 5	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 READINGS

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

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 KMnO₄.
9. Verification of Hartmann Dispersion relation

CORE COURSE 6 : MSPH222: DIGITAL ELECTRONICS LAB

List of Experiments:

1. Study of square wave generator.
2. Study of Schmitt trigger.
3. Study of flip flops.
4. Study of half adder and full adder.
5. Study of half and full subtractor.
6. Study of shift registers.
7. Study of counters.
8. Study of MOD counters.
9. Assembly language programming on 8085 microprocessor: Data transfer using direct and indirect addressing, Addition, Subtraction.
10. Assembly language programming on 8085 microprocessor: Multiplication, Division, Array Addition, Largest and smallest from a set of numbers

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

MSC PHYSICS III SEMESTER

COURSE TYPE	COURSE 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 RESOURCES (B). INTRODUCTION TO COMPUTER SIMULATION IN PHYSICS	2-0-2	-	-	-	-
TOTAL				24	180	420	600

CORE COURSE 1 : MSPH311: CLASSICAL ELECTRODYNAMICS

UNIT - 1	<p>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.</p> <p>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</p>
UNIT - 2	<p>Maxwell Equations, Macroscopic Electromagnetism, Conservation Laws: 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</p>
UNIT - 3	<p>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.</p> <p>Collisions, Energy Loss and Scattering of Charged Particles: Energy transfer in a Coulomb collision between heavy incident particle and free electron, Energy transfer to a harmonically bound charge, Thomson scattering, Cherenkov radiation</p>
UNIT - 4	<p>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</p>
UNIT - 5	<p>Dynamics of Relativistic Charged Particle: Langrangian and Hamiltonian for a relativistic charged particle in external electromagnetic fields, Motion of charged particle in uniform static magnetic field, Motion in 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</p>

SUGGESTED READINGS

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. Christy: *Foundation of Electromagnetic Theory*, 4th edition, Pearson Education, 2009

CORE COURSE 2 : MSPH312: QUANTUM MECHANICS-II	
UNIT - 1	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 - 2	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 - 3	Identical Particles: Principle of indistinguishability, 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 - 4	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 - 5	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 READINGS	
<ol style="list-style-type: none"> 1. J.J. Sakurai: <i>Modern Quantum Mechanics</i>, Addison Wesley, 2010. 2. V.K. Thankappan: <i>Quantum Mechanics, 2nd edition</i>, New Age International (P) Limited, Publishers, New Delhi, 2010 3. A. Ghatak and S. Loknathan: <i>Quantum Mechanics: Theory and Application</i>, 4th edition, Macmillan, 1999. 4. D.J. Griffith: <i>Introduction to Quantum Mechanics, 2nd edition</i>, Pearson Education, 2005 5. L.I. Schiff: <i>Quantum Mechanics, 3rd edition</i>, Mc-Graw Hill, 1968. 6. B.S. Rajput: <i>Advanced Quantum Mechanics</i>, Pragti Prakashan, Meerut, 1994 	

CORE COURSE 3 : MSPH313: NUCLEAR PHYSICS-I	
UNIT - 1	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 - 2	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's model and explanation of ground states of the nuclei
UNIT - 3	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 - 4	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 - 5	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 READINGS

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 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

Elective core course- I

Group A: ELECTRONICS

MSPH314(A): COMMUNICATION TECHNOLOGY

UNIT - 1	Analog Communication: Modulation, Need for modulation, Amplitude modulation- Mathematical analysis and generation of AM waves, DSBSC modulation, Generation of DSBSC waves, SSB modulation, Generation of SSB, Frequency modulation, Mathematical analysis and generation of FM. Demodulation: Demodulation of AM signals, Demodulation of FM signals: Foster Seeley discriminator, Ratio detector
UNIT - 2	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, Companding, Digital modulation techniques: ASK, FSK, BPSK, QPSK
UNIT - 3	Transmission Lines: Voltage and current equations of transmission lines, Characteristic impedance, Propagation constant, Reflection coefficient, VSWR, Impedance transformation, Impedance matching by single 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 - 4	Radar System: Radar block diagram and operation, Radar frequencies, Radar range equation, Minimum detectable signal, Pulsed radar system, Doppler's effect, CW Doppler Radar system, Moving target Indicator Radar, Satellite Communication: Kepler Laws, Satellite elevation categories, Satellite orbital patterns, Apogee, perigee, ascending and descending nodes, Geo-Stationary Satellite, Antenna Look angles: Azimuth and elevation angle, Satellite systems link modules: Uplink, transponder and downlink modules
UNIT - 5	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, 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

SUGGESTED READINGS

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 Pub. House, New Delhi, 1983.
1. H.A. Enge: *Introduction to Nuclear Physics*, Addison Wesley, London, 1975. Wayne Tomasi: *Introduction to Data Communication and Networking*, 1st Ed., Pearson 2007.

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

Elective Core Course-I	
Group B: MATERIAL SCIENCE	
MSPH314(B): MATERIAL SYNTHESIS AND CHARACTERIZATION	
UNIT - 1	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, Defects in crystals
UNIT - 2	Solid States and Solution Routes: Ceramic method; Mechanical mixing, Grinding, Combustion method, Co-precipitation method; Sol-gel techniques; Hydrothermal, Melt methods: Czechorlskii methods, Skull melting, Sono-chemical method
UNIT - 3	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 of cubic system, Scherrer formula for estimation of particle size, Lattice parameters calculations and other uses, Electron diffraction and its uses
UNIT - 4	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 - 5	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 READINGS	
1.	Ichiro Sunagawa: <i>Crystals: Growth, Morphology and Perfection</i> , Cambridge University Press, Cambridge, 2005.
2.	J. W. Mullin: <i>Crystallization</i> , Elsevier Butterworth-Heinemann, London, 2004.
3.	J. C. Brice: <i>Crystal Growth Processes</i> , John Wiley and Sons, New York, 1986.
4.	H. H. Willard: <i>Instrumental methods of Analysis</i> , CBS Publishers, 1986.
5.	B. D. Cullity: <i>Elements of X-ray Diffraction</i> , Addison Wesley Publishing Co., 1967.
6.	Sam Zhang, Lin Li and Ashok Kumar: <i>Materials Characterization Techniques</i> , CRC Press, 2008.
7.	Yang Leng: <i>Materials Characterization: Introduction to Microscopic and Spectroscopic Methods</i> , Wiley & Sons, 2008.
8.	Elton N. Kaufmann: <i>Characterization of Materials, Vol.1</i> , Wiley & Sons, 2003.
9.	R.A. Laudise: <i>Growth of Single Crystals</i> , Prentice Hall, 1973.
10.	G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), <i>Springer Handbook of Crystal Growth</i> , Springer Verlag, 2010

Core Course 5: MSPH311: GENERAL PHYSICS LAB	
List of Experiments:	
1.	To determine and compare slit width from the study of Fraunhofer's 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.
9.	Study of X-ray simulator.

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| 10. | Determination the diameter of Lycopodium powder using Corona ring G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), <i>Springer Handbook of Crystal Growth</i> , Springer Verlag, 2010 |
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Core Course 6: MSPH322: NUCLEAR PHYSICS LAB
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List of Experiments:

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| 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. |

Skill Course –III(A)

MSPHSC333(A): RENEWABLE ENERGY RESOURCES

<p>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.</p> <p>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</p>

SUGGESTED READINGS

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| 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, Fson & 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, Heidelberg, 2000. |
| 11. | Gary L. Johnson, Wind Energy System, Printice Hall Inc, New Jersey, 1985. |
| 12. | S.N. Bhadra, D. Kastha and S. Banerjee, Wind Electrical Systems, Oxford Univ Press 2005 |

RENEWABLE ENERGY RESOURCES LAB WORK
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| 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

Skill Course –III(B)

MSPHSC333(B): INTRODUCTION TO COMPUTER SIMULATION IN PHYSICS

Introduction to Computer Simulation: The importance of computer simulation, Programming languages and object-oriented techniques, Tools for simulations.

Random numbers, Generation of random numbers, Monte Carlo method of simulation and Molecular dynamics methods.

Simulation of particle motion in one dimension.

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

INTRODUCTION TO 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.
6. Generation of random numbers

MSC PHYSICS IV SEMESTER

COURSE TYPE	COURSE 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

CORE COURSE 1 : MSPH411: NUCLEAR PHYSICS-II

UNIT - 1	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 - 2	Nuclear Reactions: Scattering and reaction cross sections, Compound nucleus, Reciprocity theorem, Breit-Wigner one level formula, Resonance Scattering, Continuum theory, Optical model
UNIT - 3	Neutron Physics and Reactor Physics: Neutron production, Slowing down power and moderating ratio, Neutron detection, 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 - 4	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 - 5	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-Nishijima formula, Neutrinos of different flavour, Charm, Bottom and Top quarks, QCD formulated, Evidence for gluon field

SUGGESTED READINGS

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

CORE COURSE 2 : MSPH412: ATOMIC AND MOLECULAR SPECTROSCOPY

UNIT - 1	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
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UNIT - 2	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 - 3	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 ₂ O and CO ₂ molecules
UNIT - 4	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
UNIT - 5	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 READINGS

<ol style="list-style-type: none"> 1. Willard, Merritt, Dean, Settle: <i>Instrumental Methods of Analysis</i>, CBS Publishers & Distributors, Delhi, 6th Ed. 1986. 2. Colin N. Banwell and Elaine M. McCash: <i>Molecular Spectroscopy</i>, Mc-Graw Hill College; 4th Sub. Ed., 1994. 3. B. H. Bransden and Joachain: <i>Physics of Atoms and Molecules</i>, Longman, 1983. 4. V. Rajendran and A. Marikani: <i>Applied Physics</i>, TMH publication, 4th Ed., 2002. 5. P. F. Bernath: <i>Spectra of Atoms and Molecules</i>, Oxford University Press, 1995. 6. Raymond Chang: <i>Basic Principles of Spectroscopy</i>, Mc-Graw Hill, 1971. 7. P. W. Atkins: <i>Molecular Quantum Mechanics</i>, Oxford University Press, 1983. 8. B. B. Laud: <i>Lasers and Non-Linear Optics</i>, Wiley Eastern Ltd., 1991. 9. H. E. White: <i>Introduction to Atomic Spectra</i>, Tata Mc-Graw Hill. 1934. 10. G. Herzberg: <i>Molecular Spectra and Molecular Structure</i> Vol. 1, 2 & 3, Krieger Publishing Company, Malabar, 1989 & 1991. 11. D. A. Long: <i>Raman Spectroscopy</i>, Mc-Graw Hill, 1977. 12. G. M. Barrow: <i>Introduction to Molecular Spectroscopy</i>, Mc-Graw Hill, Tokyo, 1962. 13. J. M. Brown: <i>Molecular Spectroscopy</i>, Oxford University Primer, 1998. 14. J. M. Holiás: <i>Modern Spectroscopy</i>, John Wiley & Sons, England, 1987

CORE COURSE 3 : MSPH413: NANOMATERIALS

UNIT - 1	Introduction: Nano size scale, History of Nanotechnology, Quantum Mechanics and Fluctuation in nanostructure systems, Size and surface effect, 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 - 2	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 - 3	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: Self-assembly method, Bio-induced nanomaterials (using microorganism and plant extract)

UNIT - 4	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 - 5	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, Lithium-ion battery, Hydrogen storage and thermo-electrics, Environmental application, Photonic crystals

SUGGESTED READINGS

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 Wile & Sons Limited, England, 2005.
9. Yury Gogotsi (Edited): *Nanomaterials Handbook*, CRC, Taylor & Francis, New York, 2006

Core Elective Course-II

Group A: ELECTRONICS

MSPH414(A): NETWORK ANALYSIS AND MICROWAVE ELECTRONICS

UNIT - 1	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 - 2	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 - 3	Introduction: Microwave frequency bands; Limitations of conventional devices at microwave frequencies. Wave Guides: Wave propagation between parallel planes, Modes of propagation, Rectangular wave guides, Impedance concept in wave guide, Impedance measurement by VSWR, Measurement of dielectric constant at microwave frequency, Cavity resonator, Measurement of frequency
UNIT - 4	Microwave Components: Scattering matrix, Phase shifters, Directional couplers; E-plane, H-plane and Hybrid Tees, Circulator. Microwave Tubes: Velocity modulation, Basic principles and characteristics of two cavity klystron and reflex klystron; Magnetrons
UNIT - 5	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

SUGGESTED READINGS

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

Core Elective Course -II Group B: MATERIAL SCIENCE MSPH414(B): THIN FILMS	
UNIT - 1	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 - 2	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 - 3	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 - 4	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 - 5	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

SUGGESTED READINGS
<ol style="list-style-type: none"> 1. Milton Ohring: <i>The Materials Science of Thin Films</i>, Academic Press, California 1992. 2. K. L Chopra: <i>Thin Film Phenomena</i>, Krieger publishing company, Huntington, New York 1979. 3. L.I. Maissel and R. Glange: <i>Hand Book of Thin Film Technology</i>, Mc-Graw Hill, New York, 1970. 4. Donald Smith: Thin-Film Deposition: Principles and Practice, Mc-Graw Hill, 1st Ed., 1995.

Core Elective Lab-I Group A: ELECTRONICS MSPH421(A): ELECTIVE PAPER LAB
<p>List of Experiments:</p> <ol style="list-style-type: none"> 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

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 TiO₂ 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

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

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.

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 characterisation 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 TiO₂ Solar Cell Trainer Kit (Four experiments)
3. Experiments based on ferro-fluid demonstrator. (Three experiments)
4. Some simple experiments on synthesis of few nanomaterials.