Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Courses offered under the framework of Amrita Values Programmes I and II

**Message from Amma's Life for the Modern World**

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma’s guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

**Lessons from the Ramayana**

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

**Lessons from the Mahabharata**

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

**Lessons from the Upanishads**

Introduction to the Upanishads: Sruti versus Smruti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, Satyakama Jabala, Aruni, Shvetaketu.

**Message of the Bhagavad Gita**


**Life and Message of Swami Vivekananda**

Brief Sketch of Swami Vivekananda’s Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji’s life.

**Life and Teachings of Spiritual Masters India**

Sri Rama, Sri Krishna, Sri Buddha, Adi Shankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri Ramana Maharshi, Mata Amritanandamayi Devi.

**Insights into Indian Arts and Literature**

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

**Yoga and Meditation**

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali’s Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

**Kerala Mural Art and Painting**

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

**Course on Organic Farming and Sustainability**

Organic farming is emerging as an important segment of human sustainability and...
healthy life. ‘Haritamritam’ is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma’s words “it is a big step in restoring the lost harmony of nature”.

Benefits of Indian Medicinal Systems
Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India
India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is ‘Unity in Diversity’ and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India
Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

Unit 1: Introduction to management, definition, nature and importance, role and skills of a manager, Planning, nature and purpose of planning, objectives of planning, steps in planning.

Unit 2: Strategic policy, goal setting, decision making, SWOT analysis, organization structure, Departmentalization, line staff authority, principles of staffing.
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

(pseudo-unimolecular reactions) - complex reactions - equilibrium and steady state approximations - mechanism of these reactions - effect of temperature on reaction rates - Arrhenius equation and its significance, Michaelis Menden kinetics-enzyme catalysis.

Unit 4 Electrochemistry
Electrolytes - strong and weak, dilution law, Debye-Huckel theory, faraday's laws, origin of potential, single electrode potential, electrochemical series, electromotive cells, Nernst equation and its application, reference electrodes - SHE, Ag/AgCl, Calomel.

Unit 5 Photochemistry
Photochemistry, laws of photochemistry - Stark-Eistein law, Beer-Lamberts law, quantum efficiency-determination, photochemical processes - Jablonsky diagram, internal conversion, inter-system crossing, fluorescence, phosphorescence, chemiluminescence and photo sensitization, photopolymerization.

REFERENCE BOOKS:

SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

and chemical methods - empirical formula and molecular formula – Classification and Nomenclature of organic compounds, Organic reactions and their mechanisms: Electron displacement effects – inductive, electromeric, mesomeric and hyperconjugative. Reactive intermediates – carbocations, carbanions, free radicals and carbenes

Unit 4 Acids, Bases and Non-aqueous solvents
Concepts of acids and bases – hard and soft acids and bases - Pearson’s concept, HSAB principle and its application - basis for hard-hard and soft-soft interactions - non-aqueous solvents - general characteristics of non-aqueous solvent - melting point, boiling point, latent heat of fusion and vaporization, and dielectric constant - reactions such as complex formation, redox, precipitation and acid base type in non-aqueous solvents like liquid ammonia, liquid SO2 and liquid HF.

Unit 5 Coordination chemistry

TEXTBOOKS:

REFERENCES:
**SYLLABUS**  
5-yr Integrated M Sc Maths/ Physics  
2016 admissions onwards

### 16CSA107 INTRODUCTION TO PROGRAMMING IN C 3 0 0 3

**Unit 1**  

**Unit 2**  
Introduction to C, Program structure – Header and Body, use of comments, construction of the Program, /*Comments */, Body braces, File names. Getting started with compiler, Alphabets in C, Keywords in C, Rules of forming Words, Data Variables, Data Types and Rules for naming and declaring data variables.

**Unit 3**  
Basic Data Types in C, variables, Constants, and Data Types. Type Definitions, Input/Output Instructions. Operators, Decision Control Instructions: -If, If-else, If-else-if, Nested if-else, Conditions, Switch case. Loop Control Instructions: While Loop, Do While, For Loop, continue, break, goto. Storage Classes and Scoping: Auto, Register, Extern, Static.

**Unit 4**  
Arrays: Array Declaration, array Initialization, processing an Array. Two-Dimensional arrays, Multidimensional arrays, Strings, string i/o, String handling functions.

**Unit 5**  
Functions: Why use Function, Components of Function, Name, Body, Local variables, Parameters Arguments, Return Value, Prototype of a function, Rules of using a function.

Structure: Declaration, Initialisation, Accessing a Structure, Uses of Structures.

**TEXTBOOKS:**

**REFERENCES:**
2. Mastering C, K R Venugopal, S R Prasad  

### 16CSA118 ADVANCED PROGRAMMING IN C 3 0 2 4

**Unit 1** Functions  
Types of functions - User defined functions - Structure of a function – Execution Process of a function - Nesting of Functions - Sending arrays to functions – Recursion

**Unit 2** Structures  
Structure Definition - Structure Initialization - Nesting of Structure - Arrays and Structures - Structure to functions, Array of structures, pointers to structures, self-referential structures.

**Unit 3** Pointers  
Accessing the address of a variable - Declaring and initializing a pointer - Pointer to Pointer - Pointers and functions – Functions returning pointer, Pointers and Arrays – pointer to array, array of pointers, Dynamic memory allocation – malloc(), calloc(0, free()).

**Unit 4** Data Structures in C  
Overview of Data Structures - Primary Forms - Linked List, Queue, Stack

**Unit 5** File Management in C  
File Operations - I/O Operations on files - General Formats for declaring and opening a File.

The Pre Processor: Preprocessor Directives - Macro Substitution directives - Command Line Arguments - Bitwise Operators

**TEXTBOOKS:**

**REFERENCES:**
1. Let us c by Yashawant Kanetkar, 2nd ed., TMH 1996  
2. Programming in ANSI C by E balagururswamy, 2nd.  

### 16CSA192 INTRODUCTION TO PROGRAMMING LAB. I 0 0 2 1

1. Programs using various input/ output statements (scanf, printf, getchar, gets, puts, putchar)  
2. Programs using operatos and enumerated data types
S Y L L A B I

5-yr Integrated M Sc Maths/ Physics  2016 admissions onwards

3. Programs using control structures (if, if else, switch, & loops)
4. Programs using one-dimensional array
5. Programs using multidimensional array
6. Programs using strings and string handling functions
7. Functions using static, external and auto-variables
8. Programs using functions
9. Programs using structures, structure within structure.

15CUL101  CULTURAL EDUCATION I  2002

Unit 1
Introduction to Indian Culture - Introduction to Amma's life and Teachings - Symbols of Indian Culture.

Unit 2
Science and Technology in Ancient India - Education in Ancient India - Goals of Life – Purusharthas - Introduction to Vedanta and Bhagavad Gita.

Unit 3
Introduction to Yoga - Nature and Indian Culture - Values from Indian History - Life and work of Great Seers of India.

TEXTBOOKS:
1. The Glory of India (in-house publication)
2. The Mother of Sweet Bliss, (Amma's Life & Teachings)

15CUL111  CULTURAL EDUCATION II  2002

Unit 1
1. Relevance of Sri Rama and Sri Krishna in this Scientific Age
2. Lessons from the Epics of India
3. Ramayana & Mahabharata

Unit 2
4. Who is a Wise Man?
5. A Ruler's Dharma
6. The Story of King Shibi

Unit 3
7. Introduction to the Bhagavad Gita
8. Bhagavad Gita – Action without Desire

15ENG101  COMMUNICATIVE ENGLISH  2023

Objectives: To help the student to obtain ability to communicate in English; to impart an aesthetic sense and enhance creativity.

Unit 1
Parts of Speech, Tenses, Prepositions, Determiners - Agreement (Subject – Verb, Pronoun - Antecedent), Phrasal Verbs, Modifiers, Linkers/ Discourse Markers, Question Tags.

Unit 2
Paragraph writing – Cohesion - Development: definition, comparison, classification, contrast, cause and effect - Essay writing: Descriptive and Narrative.

Unit 3
Letter Writing - Personal (congratulation, invitation, felicitation, gratitude, condolence etc.) - Official (Principal/ Head of the department/ College authorities, Bank Manager, Editors of newspapers and magazines).

Unit 4

Unit 5
Short Stories: Katherine Mansfield's A Cup of Tea – Kishori Charan Das's Death of an Indian.
Poems: Maya Angelou's I Know Why the Caged Bird Sings - Sri Aurobindo's The Tiger and the Deer.

REFERENCES:
5. Murphy, Raymond, Murphy's English Grammar, CUP, 2004
7. Seely, John, Writing and Speaking, OUP, 1998

ENGL121 PROFESSIONAL COMMUNICATION 1 0 2 2

Objectives: To convey and document information in a formal environment; to acquire the skill of self projection in professional circles; to inculcate critical thinking and to improve aesthetic sense.

Unit 1

Unit 2
Instruction, Suggestion & Recommendation - Graphical Interpretation: Extracting data from charts and graphs - Essay writing: Analytical and Argumentative.

Unit 3
Circulars, Memos – Business Letters - e-mails.

Unit 4

Unit 5
Listening and Reading Practice - Book Review.

REFERENCES:
1. Felixa Eskey Tech Talk, University of Michigan, 2005


ENV300 ENVIRONMENTAL SCIENCE AND SUSTAINABILITY 3 0 0 3

Unit 1
State of Environment and Unsustainability, Need for Sustainable Development, Traditional conservation systems in India, People in Environment, Need for an attitudinal change and ethics, Need for Environmental Education, Overview of International Treaties and Conventions, Overview of Legal and Regulatory Frameworks.

Environment: Abiotic and biotic factors, Segments of the Environment, Biogeochemical Cycles, Ecosystems (associations, community adaptations, ecological succession, Food webs, Food chain, ecological pyramids), Types of Ecosystems – Terrestrial ecosystems, Ecosystem Services, Economic value of ecosystem services, Threats to ecosystems and conservation strategies.

Biodiversity: Species, Genetic & Ecosystem Diversity, Origin of life and significance of biodiversity, Value of Biodiversity, Biodiversity at Global, National and Local Levels, India as a Mega-Diversity Nation (Hotspots) & Protected Area Network, Community Biodiversity Registers. Threats to Biodiversity, Red Data book, Rare, Endangered and Endemic Species of India. Conservation of Biodiversity. People's action.

Impacts, causes, effects, control measures, international, legal and regulatory frameworks of: Climate Change, Ozone depletion, Air pollution, Water pollution, Noise pollution, Soil/ land degradation/ pollution.

Unit 2
Linear vs. cyclical resource management systems, need for systems thinking and design of cyclical systems, circular economy, industrial ecology, green technology. Specifically apply these concepts to: Water Resources, Energy Resources, Food Resources, Land & Forests, Waste management.

Discuss the interrelation of environmental issues with social issues such as: Population, illiteracy, Poverty, Gender equality, Class discrimination, Social impacts of development on the poor and tribal communities, Conservation movements: people's movements and activism, Indigenous knowledge systems and traditions of conservation.
S 13

**SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards**

**Unit 3**

Global and national state of housing and shelter, Urbanization, Effects of unplanned development case studies, Impacts of the building and road construction industry on the environment, Eco-homes/ Green buildings, Sustainable communities, Sustainable Cities.

Ethical issues related to resource consumption, Intergenerational ethics, Need for investigation and resolution of the root cause of unsustainability, Traditional value systems of India, Significance of holistic value-based education for true sustainability.

**TEXTBOOKS/ REFERENCES:**

15HIN101 HINDI I 1 0 2 2

**Objectives:** To teach Hindi for effective communication in different spheres of life: Social context, Education, governance, Media, Business, Profession and Mass communication.

**Unit 1**
Introduction to Hindi Language - National Language, Official Language, link Language etc. Introduction to Hindi language, Devanagari script and Hindi alphabet.

Shabda Bhed, Roopantar ki Drishti se - Bhasha – Paribhasha aur Bhed - Sangya - Paribhasha Aur Bhed - Sangya ke Roopantar - kriya.

**Unit 2**
Common errors and error corrections in Parts of Speech with emphasis on use of pronouns, Adjective and verb in different tenses – Special usage of adverbs, changing voice and conjunctions in sentences, gender & number - General vocabulary for conversations in given context – understanding proper pronunciation – Conversations, Interviews, Short speeches.

**Unit 3**
Poems – Kabir 1ST 8 Dohas, Surdas 1st 1 Pada; Tulsidas 1st 1 Pada; Meera 1st 1 Pada.

**Unit 4**

**Unit 5**
Kahani – Premchand: Kafan, Abhilasha, Vidroh, Poos ki rath, Juloos.

**TEXTBOOKS:**
1. Prem Chand Ki Srvashrestha Kahaniyam: Prem Chand; Diamond Pub Ltd. New Delhi
2. Vyavaharik Hindi Vyakaran, Anuvad thaha Rachana: Dr. H. Parameswaran, Radhakrishna publishing House, New Delhi

15HIN111 HINDI II 1 0 2 2

**Objectives:** Appreciation and assimilation of Hindi Literature both drisya & shravya using the best specimens provided as anthology.

**Unit 1**

**Unit 2**
Communicative Hindi - Moukhik Abhivyakthi.

**Unit 3**
Audio-Visual – Media in Hindi – Movies like Tare Zameen par, Paa, Black etc., appreciation and evaluation. News reading and presentations in Radio and TV channels in Hindi.

**Unit 4**
Gadya Manjusha – Budhapa, Kheesa, Sadachar ka Thavis.
SYLLABI  5-yr Integrated M Sc Maths/ Physics  2016 admissions onwards

Unit 5

TEXTBOOKS:
Kavay Tarang: Dr. Niranjan, Jawahar Pustakalay, Mathura.
Gadya Manjusha: Editor: Govind, Jawahar Pustakalay, Mathura

KAN101  KANNADA I  1 0 2 2

Objectives: To enable the students to acquire basic skills in functional language; to develop independent reading skills and reading for appreciating literary works; to analyse language in context to gain an understanding of vocabulary, spelling, punctuation and speech.

Unit 1
Adalitha Kannada; bhashe, swaroopa, belavanigeya kiru parichaya
Paaribhaashika padagalu
Vocabulary Building

Unit 2
Prabbandha – Vyaaghra Geethe - A.N. Murthy Rao
Prabbandha – Bareddi…bareddi, Baduku mugyuvuddilla allige… - Nemi Chandra
Paragraph writing – Development: comparison, definition, cause & effect
Essay – Descriptive & Narrative

Unit 3
Mochi – Bharateepriya
Mosarina Mangamma – Maasti Venkatesh Iyengar
Kamalaapuruda Hotelnalli – Panje Mangesh Rao
Kaanike – B.M. Shree
Geleyanobbanige bareda Kaagada – Dr. G.S. Shivarudrappa
Moodala Mane – Da.Ra. Bendre
Swanthryada Hanate – K. S. Nissaar Ahmed

Unit 4
Letter Writing - Personal: Congratulation, thanks giving, invitation, condolence

Unit 5
Reading Comprehension; nudigattu, gaadegalu
Speaking Skills: Prepared speech, pick and speak.

REFERENCES:
1. H.S. Krishna Swami Iyangar – Adalitha Kannada – Chetana Publication, Mysuru
3. Nemi Chandra – Badhuku Badalisahabudu – Navakamataka Publication
4. Sanna Kathegalu - Prasaranaga, Mysuru University , Mysuru
5. B.M. Shree – Kannadada Bavuta – Kannada Sahitya Parishattu
6. K.S. Nissar Ahmed – 75 Bhaavageetegalu – Sapna Book House (P) Ltd.
7. Dr.G.S. Shivarudrappa – Samagra Kavya – Kamadhenu Pustaka Bhavana

KAN111  KANNADA II  1 0 2 2

Objectives: To enable the students to acquire basic skills in functional language; to develop independent reading skills and reading for appreciating literary works; to develop functional and creative skills in language; to enable the students to plan, draft, edit & present a piece of writing.

Unit 1
Official Correspondence: Adhikrutha patra, prakatane, manavi patra, vanijya patra

Unit 2
Nanna Hanate - Dr.G.S. Shivarudrappa
Ella Marethiruvaga - K.S. Nissaar Ahmed
Saviraru Nadigalu – S Siddalingayya

Unit 3

Unit 4
Sarva Sollegala turtu Maha Samelana - Beechi
Swarthakkaagi Tyaga - Beechi

Unit 5
Essay writing: Argumentative & Analytical
Precis writing

REFERENCES:
1. H.S. Krishnaswami Iyengar – Adalitha Kannada – Chetan Publication, Mysuru
2. Dr.G.S. Shivarudrappa – Samagra Kavya. - Kamadhenu Pustaka Bhavana
4. K.S. Nissaar Ahmed – 75 Bhaavageetegalu – Sapna book house

Arts and Sciences  AMRITA VISHWA Vidyapeetham  S 15
Arts and Sciences  AMRITA VISHWA Vidyapeetham  S 16
 MALAYALAM I  

**Objectives:** To appreciate the aesthetics & cultural implications; to enhance creative thinking in mother-tongue; to learn our culture & values; to equip students read & write correct Malayalam; to correct the mistakes in pronunciation; to create awareness that good language is the sign of complete personality.

**Unit 1**
Ancient poet trio: Adhyatmaramayanam, Lakshmana Swanthanam (valsa soumitre... mungikidakayal), Ezuthachan - Medieval period classics – Jnanappana (kalaminnu… vlasangalingane), Poonthanam.

**Unit 2**

**Unit 3**
Short stories from period 1/2/3, Poovanpazham - Vaikaom Muhammed Basheer - Literary & Cultural figures of Kerala and about their literary contributions.

**Unit 4**
Literary Criticism: Ithihasa studies - Bharatha Paryadanam - Vyasante Chiri - Kuttkrishna Mararu - Outline of literary Criticism in Malayalam Literature - Introduction to Kutti Krishna Mararu & his outlook towards literature & life.

**Unit 5**
Error-free Malayalam: 1. Language; 2. Clarity of expression; 3. Punctuation.

**REFERENCES:**
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

16MAT107  CALCULUS  3 1 0 4

Unit 1 Limits and continuity
Rates of Change and Limits – Calculating Limits using Limiting Laws – The Precise definition of Limit – One-Sided Limits and Limits at Infinity – Continuity – Tangents and Derivatives. Chapter 2- Sec: 2.1 to 2.4, 2.6 to 2.7

Unit 2 Differentiation
The Derivative as a Function – Differentiation Rules – The Derivative as a Rate of Change – Derivatives of Trigonometric Functions – The Chain Rule and Parametric Equations – Implicit Differentiation. Chapter 3- Sec: 3.1 to 3.6

Unit 3 Application of Derivatives
Extreme values of Functions – The Mean Value Theorem – Monotonic Functions and the First Derivative Test – Concavity and Curve Sketching. Chapter 4- Sec: 4.1 to 4.4

Unit 4 Integration
Estimating with Finite Sums – Sigma Notation and Limits of Finite Sums – The Definite Integral – The Fundamental Theorem of Calculus – Indefinite Integrals and the Substitution Rule – Substitution and Area between Curves. Chapter 5- Sec: 5.1 to 5.6

Unit 5 Techniques of Integration: Basic Integration Formulas – Integration by Parts – Integration of Rational Functions by Partial Fractions – Trigonometric Integrals – Trigonometric Substitutions – Improper Integrals. Chapter 8: 8.1 to 8.5, 8.8

TEXTBOOK:

REFERENCE BOOKS:

16MAT118  VECTOR CALCULUS  3 1 0 4

Unit 1 Motion in Space: Lines and Planes in space, Cylinders and Quadric Surfaces, Vector Functions, Arc length and the unit tangent vector, Curvature and the unit normal vector, Torsion and the unit binormal vectors. Text Book 1: Sections 12.5, 12.6, 13.1, 13.3, 13.4, 13.5

SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

15MAT201  DISCRETE MATHEMATICS  3 1 0 4

Unit 1 Logic, Mathematical Reasoning and Counting: Logic, Prepositional Equivalence, Predicate and Quantifiers, Theorem Proving, Functions, Mathematical Induction. Recursive Definitions, Recursive Algorithms, Basics of Counting, Pigeonhole Principle, Permutation and Combinations. (Sections: 1.1 -1.3, 1.5 -1.7, 2.3, 4.1 - 4.4, 5.1 - 5.3 and 5.5)

Unit 2 Relations and Their Properties: Representing Relations, Closure of Relations, Partial Ordering, Equivalence Relations and partitions. (Sections: 7.1, 7.3 - 7.6)

Advanced Counting Techniques and Relations: Recurrence Relations, Solving Recurrence Relations, Generating Functions, Solutions of Homogeneous Recurrence Relations, Divide and Conquer Relations, Inclusion-Exclusion. (Sections: 6.1 - 6.6)

Unit 3 Graph Theory: Introduction to Graphs, Graph Operations, Graph and Matrices,
Graph Isomorphism, Connectivity, Euler and Hamilton Paths, Shortest Path Problem, Planar Graph, Graph Colorings and Chromatic Polynomials. (Sections: B.1 - B.8)

**TEXTBOOK:**

**REFERENCES:**

**15MAT222 DIFFERENTIAL EQUATIONS 3 1 0 4**

**Ordinary Differential Equations**

Unit 1
Review of differential equations. Exactness. Rules for finding integrating factors. Equations of first order but of higher degree. Equations solvable for \( \frac{dx}{dy}, y, x \). Methods for solving \( \frac{dx}{dy} = \frac{dy}{dx} = \frac{dz}{z} \) where P, Q and R are functions of x, y and z. Clairut's equation. Simultaneous

Unit 2
Second order linear homogeneous differential equations with constant coefficients. Second order linear nonhomogeneous differential equations. Method of undetermined coefficients. Method of variation of parameters. Method of reduction of order of linear second order differential equations with variable coefficients. Solving equations of the forms \( f(x, y') = 0, f(y, y') = 0, f(x, y', y'') = 0 \) and \( f(y, y', y'') = 0 \).

**Partial Differential Equations**

Unit 3
Formation of equations by eliminating arbitrary constants and arbitrary functions. Solutions of partial differential equations. General, particular and complete integrals. Solution of partial differential equations by direct integration. Methods to solve the first order partial differential equations of the forms \( f(p,q) = 0, f(x,p,q) = 0, f(y,p,q) = 0, f(z,p,q) = 0, f(x,p) = 1/f(p,q) \) and Clairut's form \( z = px + qy + f(p,q) \) where .

Equations reducible to standard forms. Lagrange's linear

\[
\frac{dy}{dz} - \alpha \frac{dz}{dy}, \quad \frac{dz}{dy} - \beta \frac{dy}{dz}, \quad \frac{dy}{dx}, \quad \frac{dx}{dy},
\]

Solution of subsidiary equation by the method of


**SYLLABI 5-yr Integrated M Sc Maths/Physics 2016 admissions onwards**

**Unit 4**
Classification of partial differential equations of second order. Homogeneous linear partial differential equations of higher order.

**Unit 5**
Non-homogeneous linear partial differential equations of higher order. Non-homogeneous linear differential equation \( f(D, D') z = F(x, y) \) where \( f(D, D') \) is factorisable into linear factors.

**TEXTBOOK:**

**REFERENCES:**

**15MAT224 PROBABILITY AND STATISTICS 3 1 0 4**

**Unit 1**
Probability Concepts:
Important definitions - random experiment, trial, sample space, mutually exclusive events, independent events, dependent events, equally likely events, exhaustive events – approaches to measuring probability – mathematical approach, statistical approach, axiomatic approach to probability, law of addition and multiplication of probability, conditional probability - Bayes Theorem definition and proof.

**Unit 2**
Random Variable and Distributions:
Discrete and continuous random variables – discrete and continuous distribution functions - mathematical expectation, moment generating function and characteristic function, standard distributions - discrete distributions Binomial, Poisson and Geometric - continuous distributions uniform, exponential, Gamma, Normal distributions - Chebyshev's theorem and central limit theorem.

**Unit 3**
Two dimensional random variables:
Joint, marginal and conditional probability distributions for discrete and continuous cases, stochastic independence, expectation of two dimensional random variables, conditional mean and variance, transformation of one and two random variables.

**Unit 4**
Correlation and Regression:
Introduction to simple correlation - scatter plot and correlation coefficient, properties
of correlation coefficient, rank correlation coefficient, introduction to simple regression, regression lines - least squares method for estimation of regression coefficients.

Unit 5
Theory of Estimation:

TEXTBOOK:

REFERENCES:

16MAT234 NUMERICAL METHODS 3 1 0 4

Unit 1
Roots of Transcendental and Polynomial Equations: Bisection method, Iteration methods based on first degree equation, Rate of convergence, System of nonlinear equations.

Solution of System of Linear Algebraic Equations: Iteration Methods.


Unit 2
Interpolation and Approximation: Lagrange and Newton interpolation for unequal intervals, Finite difference operators, Interpolating polynomials using finite differences.

Unit 3
Differentiation and integration: Numerical differentiation - Methods based on Interpolation, Numerical integration - Methods Based on Interpolation, Methods Based on Undetermined Coefficients.

Unit 4

Unit 5

TEXTBOOK:

REFERENCE BOOKS:

16MAT229 INTRODUCTION TO LINEAR ALGEBRA 3 1 0 4

Unit 1
System of linear equations and Matrices, Determinants. (Sec 1.1-1.7, 2.1-2.3)

Unit 2
Euclidian Vector Spaces. (Sec 3.1-4.4)

Unit 3
General Vector Spaces (Sec 5.1-5.6)

Unit 4
Inner product spaces. (Sec 6.1-6.6)

Unit 5
Eigenvalues and eigenvectors. (Sec 7.1-7.3)

TEXTBOOK:

REFERENCES:
SYLLABI  5-yr Integrated M Sc Maths/ Physics  2016 admissions onwards

16MAT238  INTRODUCTION TO MODERN ALGEBRA  3 1 0 4

Unit 1
Introduction to Groups. Symmetries of a Square. The Dihedral Groups. Definition and Examples of Groups. Elementary Properties of Groups Finite Groups; Subgroups, Terminology and Notation. Subgroup Tests, Examples of Subgroups,

Unit 2

Unit 3

Unit 4

Unit 5

TEXTBOOK:

REFERENCES:

16MAT326  INTRODUCTION TO REAL ANALYSIS  3 1 0 4

Unit 1
Preliminaries - Sets and Functions, Mathematical Induction, Finite and Infinite Sets.


TEXTBOOK:

REFERENCE BOOKS:

16MAT327  INTRODUCTION TO COMPLEX ANALYSIS  3 1 0 4

Unit 1
Definition, Algebra of complex numbers, polar forms, regions, Limits, continuity, differentiability Analyticity, CR equations, Harmonic Functions, Exponential,
trigonometric, logarithmic and hyperbolic functions, complex exponentials and Inverse trigonometric functions.

**Unit 2**
Conformal mappings, bilinear transformations, Special bilinear transformations, fixed points.

**Unit 3**
Contour integral, Cauchy-Goursat theorem, Cauchy’s integral formula, winding number, Primitives.

**Unit 4**
Sequences, series, power series, uniform convergence of power series, Taylor’s series, Laurent’s series, Integration and differentiation of Power series.

**Unit 5**
Zeros and singularities of analytic functions, types of singularities, poles, residue theorem.

**TEXTBOOK:**

**REFERENCES:**

**15MAT328 INTRODUCTION TO NUMBER THEORY 3 1 0 4**

**Unit 1 Divisibility**
Definition, properties, division algorithm, greatest integer function (Sec 1.1)

Primes: Definition, Euclid’s Theorem, Prime Number Theorem (statement only), Goldbach and Twin Primes conjectures, Fermat primes, Mersenne primes. The greatest common divisor: Definition, properties, Euclid’s algorithm, linear combinations and the GCD - The least common multiple: Definition and properties. The Fundamental Theorem of Arithmetic: Euclid’s Lemma, canonical prime factorization, divisibility, GCD, and LCM in terms of prime factorizations. Primes in arithmetic progressions: Dirichlet’s Theorem on primes in arithmetic progressions (statement only) (Sec 1.2 to 1.5).

**Unit 2 Congruences**
Definitions and basic properties, residue classes, complete residue systems, reduced residue systems - Linear congruences in one variable, Euclid’s algorithm
UNIT 1
Definition of Legendre’s Equation, Solution of Legendre’s Equation, Definition of $P_n(x)$ and $Q_n(x)$. General solution of Legendre’s equation. Orthogonal properties of Legendre’s Polynomials, Recurrence formulae, Rodrigues formula.

UNIT 2
Legendre’s functions of the Second Kind, Recurrence formulae for $Q_n(x)$, Relation between $P_n(x)$ and $Q_n(x)$. Orthogonality of Legendre Polynomials.

UNIT 3
Bessel’s equation (Def.), Solution of Bessel’s General Differential Equations, General Solution of Bessel’s Equation, Definition of $J_n(x)$, Recurrence formulae for $J_n(x)$. Orthogonality of Bessel Functions.

UNIT 4
Optimality criteria, unconstrained optimization - solution by direct substitution, unidirectional search - direct search methods evolutionary search method, Hook-Jeeves pattern search method, gradient based methods – steepest descent, Cauchy’s steepest descent method.

UNIT 5
Constrained optimization – Kuhn-Tucker conditions - transformation, Lagrangean method.

TEXTBOOK:

REFERENCES:
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 4
Design of Experiments:
Introduction – Latin Square Design – statistical model for LSD, computation of sum of squares – two factor factorial experiment – main and interaction effects.

Unit 5
Data and statistical model - computation of sum of squares – estimation of variance components.

TEXTBOOK:

REFERENCES:

MAT340 INTEGRAL TRANSFORMS AND FOURIER SERIES 3 0 0 3

Unit 1
Fourier Analysis: Fourier series, Complex Form of Fourier Series, Parseval’s Identity.

Unit 2
Fourier Integrals, Fourier integral theorem.

Unit 3
Infinite Complex Fourier Transforms, Sine and Cosine Transforms, Properties, Convolution theorem and Parseval’s theorem.

Unit 4
Laplace Transforms: Laplace Transforms, Inverse Transforms, Properties, Transforms of Derivatives and Integrals, Second Shifting Theorem, Unit Step Function and Dirac-Delta Function, Differentiation and Integration of Transforms.

Unit 5
Convolution, Initial and Final Value Theorems, Periodic Functions, Solving Linear Ordinary Differential Equations with Constant Coefficients, System of Differential Equations and Integral Equations.

TEXTBOOK:

SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

REFERENCE BOOKS:

MAT341 INTRODUCTION TO OPERATIONS RESEARCH 3 0 0 3

Unit 1 Linear Programming Problem

Unit 2 Transportation and Assignment Problems

Unit 3 Queuing Theory
Introduction to queuing theory, characteristics of queuing theory, single channel queuing models with finite and infinite size, solution to single channel queuing models.

Unit 4 Simulation
Introduction to simulation, advantages and limitations, generation of random numbers, Monte Carlo simulation, and computer aided simulation.

Unit 5 CPM and PERT
Network logic, concepts and definition, network scheduling by critical path method, program evaluation and review technique.

TEXTBOOKS and REFERENCES:
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

16MAT380  MATHEMATICAL SOFTWARE – MATLAB  0 0 2 1

Mathematical package MATLAB will be introduced to solve problems in Linear Algebra, Differential Equations, Numerical Analysis, Combinatorics, etc.


Combinatorics: Making lists of combinatorial objects, generating random combinatorial objects (like sets, permutations, partitions etc.), Tree Search, Graph search: Breadth and depth first search.

TEXTBOOKS:
2. Rudra Pratap Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers, Oxford University Press.

16MAT391  MATHEMATICS SEMINAR  0 0 2 1

Seminars shall be given in the area of Mathematics. In this one-credit course, students present and discuss the subject matter with faculty guidance. Topics presented by the students include fundamental topics. Students are exposed to areas not covered in courses and the students take turns in giving lectures. The objective of these seminars is to provide the students with training in the verbal and written communication of topics in Mathematics.

15MAT501  ADVANCED ALGEBRA  4 0 0 4

Review: Groups and Rings

Unit 1 Rings
Euclidean Rings, Polynomial Rings, Polynomial Rings over the Rational Field, Polynomial Rings over Commutative Rings. (Sec. 3.7 to 3.11).

Unit 2 Fields
Definition of Fields, Field Extensions, Finite, Algebraic Field Extensions and Their Properties. The Transcendence of ‘e’. (Sec. 5.1 to 5.2).

Unit 3 Fields (contd)
Roots of Polynomials, Remainder Theorem, Splitting Field and its Uniqueness, Classical Ruler and Compass Constructions, Distinct and Multiple Roots, Simple Extension of a Field. (Sec. 5.3 to 5.5).

SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 4 Fields (contd)
The Elements of Galois Theory, Solvability by Radicals, Galois Groups over the Rationals. (Sec. 5.6 to 5.8).

Unit 5 Groups
Direct products, Finite Abelian Groups. (Sec. 2.13 and 2.14).

(Seminar/self study topics)

TEXTBOOKS:

REFERENCES:

15MAT502  ADVANCED REAL ANALYSIS  4 0 0 4

Unit 1 Functions of Bounded Variation and Rectifiable Curves
Introduction, Properties of monotonic functions, Functions of bounded variation, Total Variation, Additive property of total variation, Total variation on \([a, x]\) as a function of \(x\).

Unit 2
Functions of bounded variation expressed as the difference of increasing functions, Continuous functions of bounded variation. (Chapter 6: 6.1-6.8)

Unit 3

Unit 4
Sequences and Series of Functions: Sequence of functions and its point-wise limit, Discussion of main problems, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation, Equicontinuous Families of Functions, The Stone-Weierstrass Theorem.

Unit 5
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

TEXTBOOK:

REFERENCE BOOKS:

15MAT503 TOPOLOGY 4 0 0 4

Unit 1
Metric Spaces: General Properties: Examples of Metric Spaces – Open Sets, Closed Sets and Convergence Sequences – Continuous Mappings between Metric Spaces – Complete Metric Spaces – Compact Metric Spaces – Separable Metric Spaces. Chapter 9: Sec 9.1 to 9.6 (Text Book 1)

Unit 2

Unit 3

Unit 4
Connectedness and Compactness: Connected Spaces – Connected Subspaces of the Real Line – Compact Spaces – Compact Subspaces of the Real Line. Chapter 3: Sec 23, 24, 26, 27 (Text Book 2)

Unit 5
Countability and Separation Axioms: The Countability Axioms – The Separation Axioms – Normal Spaces – Te Urysohn Lemma – The Urysohn Metrization Theorem. Chapter 4: Sec 30 to 34 (Text Book 2)

TEXTBOOKS:


REFERENCE BOOKS:
1. J. Dugundji: Topology (Allyn and Bacon, Boston, 1966.)

15MAT504 ORDINARY DIFFERENTIAL EQUATIONS 4 0 0 4

Unit 1

Unit 2

Unit 3
Complex n-dimensional space, Systems as vector equations, Existence and uniqueness of solutions to systems, Existence and Uniqueness of linear systems, Equations of order n.

Unit 4

Unit 5

Oscillations and the Sturm Separation theorem, The Sturm comparison theorem.

TEXTBOOKS:

REFERENCE:
Ordinary differential equations and stability theory, S.G Deo and V Raghavendra
**SYLLABI**  
5-yr Integrated M Sc Maths/ Physics  
2016 admissions onwards

**15MAT511**  
**ADVANCED COMPLEX ANALYSIS**  
4 0 0 4  

Unit 1  
Analytic Continuation: Direct Analytic Continuation, Monodromy Theorem, Poisson Integral Formula, Analytic Continuation via Reflection.

Unit 2  
Representations for Meromorphic and Entire Functions: Infinite Sums and Meromorphic functions, Infinite Product of Complex Numbers, Infinite Products of Analytic Functions.

Unit 3  

Unit 4  
Mapping Theorems: Open Mapping Theorem and Hurwitz' Theorem, Basic Results on Univalent Functions, Normal Families.

Unit 5  

**TEXTBOOK:**  

**REFERENCES:**  
1. T.W. Gamelin, Complex Analysis, Springer-Verlag, 2001  

**15MAT512**  
**FUNCTIONAL ANALYSIS**  
4 0 0 4  

Unit 1  
Normed Linear Spaces: Linear Spaces – Normed Linear Spaces – The Metric on a Normed Linear Space – Linear Subspaces – Bounded Linear Transformations.  
*Sections: 3.1 to 3.5 (Text Book – 1)*

Unit 2  
Linear Homeomorphisms – An Elementary Integral – Regulated Mappings – Integration and Differentiation - Review of Compact Metric Spaces – Basic Results on Compact Subsets of a Metric Space – Separability of Compact Metric Spaces – Conditions Equivalent to Compactness - Borel-Lebesgue Theorem.  
*Sections: 3.7 to 3.9 and 4.1 to 4.2 (Text Book – 1)*

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5-yr Integrated M Sc Maths/ Physics  
2016 admissions onwards

**Unit 3**  
*Sections: 4.3 to 4.6 (Text Book – 1)*

**Unit 4**  
*Sections: 5.1 to 5.4 (Text Book – 1)*

**Unit 5**  
A Theorem on Convex Sets – The Riesz Representation Theorem – Herglotz’s Theorem.  
*Sections 5.5 to 5.7 (Text Book – 1)*

**TEXTBOOKS:**  

**15MAT513**  
**GRAPH THEORY**  
4 0 0 4  

Unit 1  

Trees: Trees, cut-edges and cut-vertices, spanning trees, minimum spanning trees, DFS, BFS algorithms.

Unit 2  
Connectivity: Graph connectivity, k-connected graphs and blocks.


Unit 3  
Unit 4

Unit 5

TEXTBOOK:

REFERENCES BOOKS:

15MAT514 PARTIAL DIFFERENTIAL EQUATIONS 4004

Unit 1
First order PDE
Geometrical Interpretation of a First-Order Equation, Method of Characteristics and General Solutions, Canonical Forms of First-Order Linear Equations.

Unit 2
Second-Order Linear Equations
Second-Order Equations in Two Independent Variables, Canonical Forms, Equations with Constant Coefficients.

Unit 3
Cauchy Problem and Wave Equations

Unit 4
Boundary-Value Problems
Boundary-Value Problems, Maximum and Minimum Principles, Uniqueness and Continuity Theorems.

Unit 5

TEXTBOOK:

REFERENCES:

15MAT601 ADVANCED TOPOLOGY 4004

Unit 1 Countability and Separation Axioms

Unit 2 Metrization and Paracompactness

Unit 3 Complete metric spaces
Compactness in metric spaces. Pointwise and compact convergence. And Ascoli’s theorem.

Unit 4 Baire spaces
Introduction to dimension theory.

Unit 5 Introduction to Fundamental group

TEXTBOOK:

REFERENCE BOOKS:
1. J. Dugundji: Topology (Allyn and Bacon, Boston, 1966.)
SYLLABI
5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 2
Integration of Functions of a Real Variable: Integration of Non-Negative Functions - The General Integral - Integration of Series - Riemann and Lebesgue Integrals. (Sections 3.1 to 3.4)

Unit 3
Abstract Measure Spaces: Measures and Outer Measures - Extension of a Measure - Uniqueness of the Extension - Completion of a Measure - Measure Spaces - Integration with Respect to a Measure (Sections 5.1 to 5.6).

Unit 4
Inequalities and the Lp Spaces: The Lp Spaces - Convex Functions - Jensen's Inequality - The Inequalities of Holder and Minkowski - Completeness of L p(µ). (Sections 6.1 to 6.5)

Unit 5
Signed Measures and their Derivatives: Signed Measures and the Decomposition - The Jordan Decomposition - The Radon-Nikodym Theorem - Some Applications of the Radon-Nikodym Theorem (Sections 8.1 to 8.4).

TEXTBOOK:

REFERENCE BOOK:

15MAT604 OPERATOR THEORY 4 0 0 4

Unit 1

Unit 2

Unit 3
Baire’s Theorem – Nowhere Differentiable Continuous Functions – Pointwise Limits of Continuous Functions – The Principle of Uniform Boundedness – The Open Mapping Theorem – The Closes Graph Theorem. Sections: 8.1 to 8.5 and 8.8 (Text Book – 1)

SYLLABI
5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 4

Unit 5

TEXTBOOKS:

15MAT605 DIFFERENTIAL GEOMETRY 4 0 0 4

Unit 1
Curves in the plane and in space, arc-length, re-parameterization, level curves vs parameterized curves, curvatures, plane curves, space curves - global properties of curves, the isoperimetric inequality, the four-vertex theorem.

Unit 2
Surfaces in three dimension, smooth surfaces, tangents, normals and orientability, quadratic surfaces, triply orthogonal systems.

Unit 3
Applications of inverse function theorem, the first fundamental form, lengths of curves of surfaces, isometric surfaces, conformal mapping of surfaces, surface area, equilateral maps and a theorem of Archimedes.

Unit 4
Curvature of surfaces, the second fundamental form, the curvature of curves on a surface, the normal and principal curvatures, geometric interpretation of principal curvatures.

Unit 5
The Gaussian curvature and the mean curvatures, flat surfaces, surfaces of a constant mean curvature, Gaussian curvature of a compact surfaces, the Gauss map.
S Y L L A B I
5-yr Integrated M Sc Maths/Physics
2016 admissions onwards

T E X T B O O K:

R E F E R E N C E  B O O K S:

1 5 M A T 6 3 1
A L G E B R A I C  G E O M E T R Y  3 0 0 3

Unit 1 Affine and Projective Varieties
Noetherian rings and modules; Emmy Noether’s theorem and Hilbert’s Basisatz; Hilbert’s Nullstellensatz; Affine and Projective algebraic sets; Krull’s Hauptidealsatz; topological irreducibility, Noetherian decomposition; local ring, function field, transcendence degree and dimension theory; Quasi-Compactness and Hausdorffness; Prime and maximal spectra; Example: linear varieties, hypersurfaces, curves.

Unit 2 Morphisms
Morphisms in the category of commutative algebras over a commutative ring; behaviour under localization; morphisms of local rings; tensor products; Product varieties; standard embeddings like the segre- and the d-uple embedding.

Unit 3 Rational Maps
Relevance to function fields and birational classification; Example: Classification of curves; blowing-up.

Unit 4 Nonsingular Varieties
Nonsingularity; Jacobian Criterion; singular locus; Regular local rings; Normal rings; normal varieties; Normalization; concept of desingularisation and its relevance to Classification Problems; Jacobian Conjecture; relationships between a ring and its completion; nonsingular curves.

Unit 5 Intersections in Projective Space
Notions of multiplicity and intersection with examples.

T E X T B O O K/ R E F E R E N C E  B O O K S:

S Y L L A B I
5-yr Integrated M Sc Maths/Physics
2016 admissions onwards

1 5 M A T 6 3 2
A L G E B R A I C  T O P O L O G Y  3 0 0 3

Unit 1

Simplicial Homology Groups: Chains, cycles, Boundaries and homology groups. Examples of homology groups; The structure of homology groups.

Unit 2
The Euler Poincare’s Theorem; Pseudomanifolds and the homology groups of Sn. [Chapter 1 Sections 1.1 to 1.4 & Chapter 2 Sections 2.1 to 2.5 from the text].

Unit 3
Simplicial Approximation: Introduction; Simplicial approximatin; Induced homomorphisms on the Homology groups; The Brouwer fixed point theorem and related results.

Unit 4
The Fundamental Group: Introduction; Homotopic Paths and the Fundamental Group; The Covering Homotopy Property for S1. [Chapter 3 Sections 3.1 to 3.4; Chapter 4 Sections 4.1 to 4.3].

Unit 5
Examples of Fundamental Groups; The Relation Between H1(K) and p1(iKi); Covering Spaces: The definition and some examples. Basic properties of covering spaces. Classification of covering spaces. Universal covering spaces. Applications. [Chapter 4: Sections 4.4, 4.5; Chapter 5 Sections 5.1 to 5.5 from the text]

T E X T B O O K:

R E F E R E N C E S:

1 5 M A T 6 3 3
C O D I N G  T H E O R Y  3 0 0 3

Unit 1
Introduction to linear codes and error correcting codes, Encoding and decoding of a linear code.

T E X T B O O K:
Art and Sciences AMRITA VISHWA Vidyapeetham S 43

T E X T B O O K:
Art and Sciences AMRITA VISHWA Vidyapeetham S 44
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 2
Dual codes. Hamming codes and perfect codes.

Unit 3
Cyclic codes. Codes with Latin Squares, Introduction to BCH codes, Reed Solomon Codes.

Unit 4
Weight Enumerators and MDS codes.

Unit 5
Linear coding theory problems and conclusions.

TEXTBOOKS:

REFERENCES:

15MAT634 COMMUTATIVE ALGEBRA 3 0 0 3

Unit 1
Rings and ideals, modules and operations on them (tensor product, Hom, direct sum and product).

Unit 2
Rings and modules of Fractions, primary decomposition.

Unit 3
Integral dependence and Valuations, Chain Conditions.

Unit 4
Noetherian Rings and Artin Rings.

Unit 5
Discrete valuation Rings and Dedekind Domains, Dimension theory.

TEXTBOOKS/REFERENCES:

15MAT635 LIE ALGEBRA 3 0 0 3

Unit 1

Unit 2

Unit 3
Semisimple Lie Algebras - Theorems of Lie and Cartan, Jordan-Chevalley Decomposition, Cartan's Criterion. (Book 1, Chapter 4).

Unit 4
Killing Form, Inner Derivations, Abstract Jordan Decomposition, Complete Reducibility of Lie algebras. (Book 1, Chapter 5).

Unit 5
The Weyl Group, Root Systems. (Book 1, Chapter 10).

TEXTBOOKS/REFERENCE BOOKS:

15MAT636 THEORY OF MANIFOLDS 3 0 0 3

Unit 1
Definition of Manifolds, Differentiable and Analytic Manifolds, Examples of Manifolds, Product of Manifolds, Mappings between Manifolds, Submanifolds, Tangent Vectors.

Unit 2
Syllabi 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 3

Unit 4

Unit 5

Textbooks/ References:

15MAT641 Fixed Point Theory 3 0 0 3

Unit 1
Contraction Principle, and its variants and applications.

Unit 2
Fixed points of non-expansive maps and set valued maps, Brouwer-Schauder fixed point theorems.

Unit 3
Ky Fan Best Approximation Theorem, Principle and Applications of KKM - maps, their variants and applications.

Unit 4
Fixed Point Theorems in partially ordered spaces and other abstract spaces.

Unit 5
Application of fixed point theory to Game theory and Mathematical Economics.

Textbooks/ Reference Books:

15MAT642 Fractals 3 0 0 3

Unit 1
Classical Fractals, Self-similarity, Metric Spaces, Equivalent Spaces.

Unit 2
The Space of Fractals, Transformation on Metric Spaces.

Unit 3
Contraction Mapping and Construction of fractals from IFS.

Unit 4
Fractal Dimension, Hausdorff measure and dimension, fractal Interpolation Functions.

Unit 5
Hidden Variable FIF, Fractal Splines, Fractal Surfaces, Measures on Fractals.

Text/ Reference Books:

15MAT643 Harmonic Analysis 3 0 0 3

Unit 1

Unit 2
Summability – Metric theorems – Pointwise summability – Positive definite sequences – Herglotz’s theorem – The inequality of Hausdorff and Young.

Unit 3
The Fourier integral – Kernels on R. The Plancherel theorem – Another convergence theorem – Poisson summation formula – Bachner’s theorem – Continuity theorem.
Unit 4
Characters of discrete groups and compact groups – Bochner's theorem – Minkowski's theorem.

Unit 5
Hardy spaces - Invariant subspaces – Factoring F and M. Rieza theorem – Theorems of Szego and Beurling.

TEXTBOOK:
Henry Helson, Harmonic Analysis, Hindustan Book Agency, Chapters 1.1 to 1.9, 2.1 to 3.5 and 4.1 to 4.3.

15MAT644 NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS 3 0 0 3

Review of first order equations and characteristics.

Unit 1
Weak solutions to hyperbolic equations - discontinuous solutions, shock formation, a formal approach to weak solutions, asymptotic behaviour of shocks.

Unit 2
Diffusion Processes - Similarity methods, Fisher's equation, Burgers' equation, asymptotic solutions to Burgers' equations.

Unit 3
Reaction diffusion equations - traveling wave solutions, existence of solutions, maximum principles and comparison theorem, asymptotic behaviour.

Unit 4
Elliptic equations - Basic results for elliptic operators, eigenvalue problems, stability and bifurcation.

Unit 5
Hyperbolic system.

TEXTBOOK:

SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

15MAT651 QUEUING THEORY AND INVENTORY CONTROL THEORY 3 0 0 3

Unit 1
Inventory concept – Components of Inventory model.

Unit 2
Deterministic Continuous Review model - Deterministic Periodic Review model.

Unit 3
The classical EOQ – Non-zero lead time – EOQ with and without shortages.
Unit 4
Deterministic Multiechelon Inventory models for supply chain management.

Unit 5
A stochastic continuous review model – A stochastic single period model for perishable products.

TEXTBOOKS:

15MAT652 RANDOM PROCESS 3 0 0 3

Unit 1 Probability and Statistics
Review of one and two random variables, stochastic independence of random variables, Poisson, uniform, exponential and normal distributions, Chebyshiev’s theorem central limit theorem, transformation of random variables, covariance and correlation, bivariate normal distribution function.

Unit 2 Random Processes

Unit 3 Special Processes
Binomial and Poisson processes - Poisson points, properties and theorems on Poisson process - Gaussian processes - description of normal processes, first and second order normal processes, standard normal process, processes depending on Gaussian process, random walk and Wiener process

Unit 4 Spectrum estimation
Introduction - Ergodicity, ensemble and time averages, types of ergodic processes - mean ergodic theorem - Power spectrum – power spectral density function and properties, Wiener-Khinchine theorem, systems with stochastic inputs.

Unit 5 Markov process – Markov chains

TEXTBOOKS:

REFERENCES:
15MAT654  STATISTICAL QUALITY CONTROL AND SIX SIGMA QUALITY ANALYSIS  3 0 0 3

15MAT655  THEORY OF SAMPLING AND DESIGN OF EXPERIMENTS  3 0 0 3
SYLLABI  5-yr Integrated M Sc Maths/ Physics  2016 admissions onwards

Unit 3
Time series as a discrete parameter stochastic process, auto covariance and auto correlation functions and their properties, stationary processes, test for stationarity, unit root test, stationary processes in the frequency domain, spectral analysis of time series.

Unit 4
Detailed study of the stationary processes: moving average (MA), autoregressive (AR), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.

Unit 5
Estimation of ARMA models, maximum likelihood method (the likelihood function for a Gaussian AR(1) and a Gaussian MA(1)) and Least squares, Yule-Walker estimation for AR Processes, choice of AR and MA periods, forecasting, residual analysis and diagnostic checking.

TEXTBOOKS:

15MAT661  ADVANCED BOUNDARY LAYER THEORY  3 0 0 3

Unit 1
Introduction – limitations of ideal fluid dynamics – Importance of Prandtl’s boundary layer theory – boundary layer equations in two dimensional flows – boundary layer flow over a flat plate – Blasius solution – Boundary layer over a wedge.

Unit 2
Energy integral equation for two-dimensional laminar boundary layers in incompressible flow – application of Von Karman’s integral equations to boundary layer with pressure gradient.

Unit 3
Displacement, momentum, energy thickness – axially symmetric flows – momentum equation for laminar boundary layer by von Karman – Wall shear and drag force on a flat plate due to boundary layer – coefficient of drag. Boundary layer equations for a 2D viscous incompressible fluid over a plane wall – Similar solutions – Separation of boundary layer flow.

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Unit 4

Unit 5
Polhausen’s method of exact solution for the velocity and thermal boundary layers in free convection from a heated plate – thermal energy integral equation. Boundary layer control using suction and injection.

TEXTBOOKS/ REFERENCES:

15MAT662  COMPUTATIONAL FLUID DYNAMICS  3 0 0 3

Unit 1
Review of Conservation equations for mass, momentum and energy; coordinate systems; Eulerian and Lagrangian approach, Conservative and non-conservative forms of the equations, rotating co-ordinates.

Unit 2
Classification of system of PDEs: parabolic elliptic and hyperbolic; Boundary and initial conditions; Overview of numerical methods; Review of Finite Difference Method. Introduction to integral method, method of weighted residuals, finite elements finite volume method & least square method.

Unit 3

Unit 4
Advanced Finite Volume methods: FV discretization in two and three dimensions, SIMPLE algorithm and flow field calculations, variants of SIMPLE, Turbulence and turbulence modelling, illustrative flow computations.

Unit 5
Introduction to turbulence modelling, CFD methods for compressible flows.
TEXTBOOKS/REFERENCE BOOKS:

15MAT663  FINITE ELEMENT METHODS  3 0 0 3

Unit 1

Unit 2
Global and local finite element models in one dimension - derivation of finite element equation.

Unit 3
Finite element interpolation - polynomial elements in one dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite elements for rectangular elements - global interpolation functions.

Unit 4
Local and global forms of finite element equations - boundary conditions - methods of solution for a steady state problem - Newton-Raphson continuation.

Unit 5
One dimensional heat and wave equations.

TEXT AND REFERENCE BOOKS:

15MAT664  MAGNETO-HYDRO DYNAMICS  3 0 0 3

Unit 1

Unit 2
Magnetohydrostatics and steady states – Hydromagnetic equilibria and Force free magnetic fields – Chandrasekhar’s theorem – General solution of force free magnetic field when is constant – Some examples of force free fields.
energy theorem. Viscous Incompressible flow - Dimensional Analysis – Buckingham theorem.

Unit 5

TEXTBOOKS/REFERENCES:

15MAT671 DATA STRUCTURES AND ALGORITHMS 3 0 0 3

Unit 1

Unit 2

Unit 3

Unit 4
Graph traversal (DFS, BFS with analysis) – biconnected components – strong connectivity; shortest path algorithms (along with analysis) – Dijkstra – Bellman Ford – Floyd Warshall. All pairs shortest path algorithm – minimum spanning tree (with analysis) – Kruskal – Prim’s – Baruvka’s.

Unit 5
NP problems: definition, P, NP, NP complete, NP hard & co-NP, examples – P, NP.

TEXTBOOK:

REFERENCES:

15MAT672 ADVANCED GRAPH THEORY 3 0 0 3

Unit 1
Binomial coefficients, convexity. Inequalities: Jensen’s, AM-GM, Cauchy Schwarz. Graphs, subgraphs, connectedness.

Unit 2
Euler circuits, cycles, trees, bipartite graphs and other basic concepts.

Unit 3
Vertex colourings. Graphs with large girth and large chromatic number.

Unit 4
Extremal graph theory: Dirac’s theorem. Ore’s theorem. Mantel’s theorem. Turan’s theorem (several proofs including probabilistic and analytic).

Unit 5

TEXT AND REFERENCE BOOKS:
1. B Bollobas, Modern Graph Theory, Springer
2. D.B. West, Introduction to Graph Theory, P.H.I. 2010

15MAT673 COMPUTER AIDED DESIGN OF VLSI CIRCUITS 3 0 0 3

Unit 1

Unit 2
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 3

Unit 4
Routing and Compaction: Types of Routing Problems – Area Routing – Channel Routing – Global Routings.

Unit 5
1D and 2D Compaction. Gete level – Switch level Modeling and Simulations.

TEXTBOOKS/ REFERENCES:

15MAT674 CRYPTOGRAPHY 3 0 0 3

Unit 1
Classical ciphers: Cryptanalysis of classical ciphers, Probability theory, Perfect security.

Block ciphers: DES, AES, Block cipher modes of operation.

Unit 2
Private-key encryption: Chosen plaintext attacks, Randomised encryption, Pseudorandomness, Chosen cyphertext attacks.

Unit 3
Message authentication codes: Private-key authentication, CBC-MAC, Pseudorandom functions, CCA-secure private-key encryption.

Unit 4
Hash function: Integrity, Pre-image resistance, 2nd pre-image resistance, Collision freeness.

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Key distribution: Key distribution centres, Modular arithmetic and group theory, Diffie-Hellman key exchange.

Unit 5

Digital Signatures: RSA signatures, RSA-FDH and RSA-PSS signatures, DSA signatures.

TEXT/ REFERENCE BOOKS:

15MAT675 FUZZY SETS AND ITS APPLICATIONS 3 0 0 3

Unit 1

Unit 2

Unit 3
Fuzzy Relations: Binary Fuzzy relations, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations.

Unit 4
Fuzzy Logic: Classical Logic, Multivalued Logic, Fuzzy Propositions, Fuzzy Quantifiers, Linguistic Hedges, Inference from Conditional Fuzzy Propositions, Conditional and Qualified Propositions and Quantified Propositions.

Unit 5
TEXT AND REFERENCE BOOKS:

**15MAT676** INTRODUCTION TO SOFT COMPUTING 3 0 0 3

Unit 1
Soft Computing: Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing.

Unit 2
Artificial Intelligence: Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies.

Unit 3
Fuzzy Logic: Crisp set and Fuzzy set, basic concepts of fuzzy sets, membership functions. Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations, Propositional logic and Predicate logic, fuzzy If – Then rules, fuzzy mapping rules and fuzzy implication functions, Applications.

Unit 4

Unit 5
Genetic Algorithms: Basic concepts of genetic algorithms, encoding, genetic modeling.


TEXT AND REFERENCE BOOKS:
3. J. Yen and R. Langari. Fuzzy Logic, Intelligence, Control and Information, Pearson Education.

**15MAT677** OBJECT-ORIENTED PROGRAMMING AND PYTHON 3 0 0 3

Unit 1


Unit 2

Unit 3
Function and class templates - Exception handling – try-catch-throw paradigm – exception specification – terminate and Unexpected functions – Uncaught exception.

Unit 4

Unit 5
Python Programming.

TEXTBOOK:

REFERENCES:

**15MAT696** DISSERTATION 10 cr

Every student is required to register for a project under a faculty member, within or outside the Department. At the completion of the Project work, the student will

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submit a bound volume of the project report in the prescribed format. The project work will be evaluated by a team of duly appointed examiners. The evaluation is based on contents, presentation and viva-voce.

16MPJ390 LIVE-IN-LAB. 3 cr

This initiative is to provide opportunities for students to get involved in societal problems which need scientific solutions. The students shall visit villages or rural sites during vacation (after fourth semester) and if they identify a worthwhile project, they will register for a 3-credit Live-in-Lab project, in the fifth semester. The objectives and projected outcome of the project will be reviewed and approved by the departmental chairman and a faculty will be assigned as the project guide. On completion of the project, the student shall submit a detailed project report. The report will be evaluated by a panel of experts.

16MPJ399 PROJECT (for exit-option students) 6 cr

Students interested in exercising the exit-option at the end of the sixth semester, shall decide on it at the end of the fourth semester. Such students should do an additional six-credit project.

The proposed project work shall get started at the beginning of the fifth semester and is to be credited during the sixth semester. The project work should be done under the supervision of the faculty members from the respective disciplines. Projects can be something like learning a chapter in a text book and writing it elaborately or it can be some survey projects and interpreting the results or making working models in Physics or developing Mathematical models for engineering and science problems.

At the end of the fifth semester, there shall be a review of the ongoing project. The students should give a presentation of the project at the end of the sixth semester.

15OEL231 – 2xx OPEN ELECTIVES 3 0 0 3

Open electives syllabi – see at the end of the booklet.

15PHY103 MECHANICS 3 1 0 4

Unit 1 Motion
Motion in 1D; vectors, motion in 2D & 3D, projectile and uniform circular motion; relative motion and relative velocity.

TEXTBOOK:
Halliday, Resnick, and Walker, Fundamentals of Physics, 8th Extended Ed., Wiley India Reprint, 2008, Chap. 1-12, 15

REFERENCES:
1. Young and Freedman, University Physics, 11th Ed, Dorling Kindersley India, 2006

15PHY113 ELECTRICITY AND MAGNETISM 3 1 0 4

Unit 1 Electric forces and fields
Electric forces, charges, conservation of charge, superposition of electric forces; electric fields, calculation of electric fields of static discrete and continuous charge distributions; Gauss’ law and determination of electric fields of simple symmetric charge distributions.

Unit 2 Electric potential and Capacitors
Electrical potential energy and electric potential of discrete and continuous distributions of charges; calculating electric field from potential; potential energy of system of point charges; capacitors and dielectrics.
Unit 3 Magnetostatics
Force due to magnetic fields, Hall effect, circular and helical orbits, magnetic force on a current carrying wire, torque on a current loop, magnetic dipole moment; calculation of magnetic field from current sources using Biot-Savart’s law and Ampere’s law; solenoids and toroids.

Unit 4 Changing magnetic fields
Faraday’s law, Electromagnetic Induction, Self & mutual inductance; Magnetism in matter and Maxwell’s equations.

Unit 5 DC and AC Circuits
Electric current, resistance, resistivity, microscopic view; DC circuits involving resistance and capacitance; AC Circuits, RLC circuits, transformers.

TEXTBOOK:

REFERENCES:
2. Young and Freedman, University Physics, 11th Ed, Dorling Kindersley India, 2006

15PHY184 PHYSICS LAB. I
List of experiments:
1. Surface Tension – Capillary Rise Method.
2. Coefficient of Viscosity - Stoke’s Method.
3. The Torsion Pendulum.
   b. The Rigidity Modules of the Material of Wire.
7. Laser - Wave length of Laser beam.
8. Laser - Slit Width of the given slit.

15PHY186 PHYSICS LAB. II
List of experiments:
1. Lee’s disc – Thermal Conductivity of a bad conductor.

16PHY200 HISTORY AND PHILOSOPHY OF SCIENCE
Unit 1
Why History of Science?
Astronomy in the ancient world - people, theory and instruments - Astronomy across civilizations of the old world, main discoveries, their contribution and instruments during those times.

Unit 2
The Dark ages in Europe - the Arabian influence - The Islamic science, translations and original contributions of Arabians, dark ages Europe, logic, literature and scientific method, early universities of Europe.

Unit 3
Indian tradition in Science and Technology - an overview - Indian contributions in science and technology - mathematics, astronomy and other sciences.

Unit 4
Texts that changed the course of history science - Elements of Euclid, Aryabhatiya of Aryabhata, Brahma-sputa Sidhanta of Brahmagupta, Yuktibhasa of Jyestadeva, Philosophiae Natturalis Principia Mathematica.

Unit 5
The Copernican revolution and the rise of modern science - The background of Copernican revolution, interaction between civilizations, the rise of modern sciences - when and why?

TEXT AND BACKGROUND LITERATURE:
History and philosophy of science is yet to be established as full-fledged discipline. A suggested anthology of reading materials:
1. Essential reading on history of sciences (in-house publication)
Unit 1
Voltage and current - resistors, voltage dividers, voltage and current sources, Thévenin’s theorem, sinusoidal signals, signal amplitudes and decibels, other signals, logic levels, signal sources.

Unit 2
Conduction in metals, semiconductors and insulators, intrinsic semiconductors, n and p materials, conduction by drift and diffusion, The p-n junction, Fermi level of pn junction, diode equation, Hall effect, diode characteristics, capacitance of a p-n junction, rectification, rectifier configurations for power supplies, circuit applications of a diode as a switch, clipping, clamping, different types of diodes - Zener diodes, LEDs, diode lasers, photodiodes, etc.

Unit 3
Transistors - npn and pnp, transistor characteristics - CB, CE and CC configurations, relation between a, b and g, transistor switch, transistor biasing. Feedback circuits. Transistor action, emitter follower, Transistor applications as amplifier. RC coupled amplifier.

Unit 4
Transistor as an oscillator, FET, JFET, MOSFET, etc.

Operational amplifiers; differential amplifier, inverting and non-inverting amplifiers. Op-amp applications-integrator, differentiator, adder etc. ICs – examples.

Unit 5
Digital electronics: Digital versus analog, logic gates, truth table, discrete circuits for gates, logic identities, minimization and Karnaugh maps.

TEXTBOOK:

REFERENCES:
3. Horowitz and Hill, The art of Electronics (Cambridge University press)
minimum energy principles, equilibrium & stability; Phase transition: first- & second-order transitions, conditions for phase coexistence, Clapeyron equation.

**TEXTBOOK:**

**REFERENCES:**
1. K. Huang, Introduction to Statistical Physics, 2nd Ed., CRC Press, 2009 (Ch. 1-4)

**16PHY215 OSCILLATIONS, WAVES AND OPTICS 3 1 0 4**

**Unit 1**
Oscillations & Waves: Simple harmonic oscillations in physical systems, damped & driven oscillations, resonance; Superposition of two oscillations, Lissajous figures. Wave equation in 1D, standing and travelling waves, energy density and transmission; superposition, group and phase velocities; characteristics of waves in 2D & 3D; sound waves in media, Doppler effect; Basics of electromagnetic waves, energy density, transport, intensity, radiation pressure, EM spectrum, light & photons.

**Unit 2**
Geometrical optics: Propagation light and dispersion in matter, Rayleigh scattering, index of refraction; Fermat’s principle, laws of reflection and refraction from Fermat’s principle; total internal reflection, evanescent wave, beam splitters; Lenses: refraction at spherical surfaces, thin lenses, lateral and longitudinal magnifications, combination of thin lenses; thick lenses and lens systems, cardinal points.

**Unit 3**
Mirrors: plane & spherical mirrors; Prisms: dispersing and reflecting types; Aberrations; A selection of topics in optical systems: Eyes, microscopes, camera and telescopes; Basic ideas on fibre-optics, transmission of light in fibres, coherent bundle, numerical aperture, fibre-optic communications.

**Unit 4**
Interference: spatial and temporal coherence; interference by division of wave front: Young’s double slit, Fresnel’s biprism; interference by division of amplitude: thin films and air wedges, fringes of equal inclination and thickness, Newton’s rings, Michelson' interferometer; Multiple beam interference, application to Fabry-Perot interferometer, AR and HR coatings.

**16PHY282 BASIC ELECTRONICS LAB. 0 0 2 1**

List of Experiments -
Familiarization of devices and equipment; Diode Characteristics; Rectifiers – Half-wave and Bridge Rectifiers; Clipper and Clamper circuits; Zener Diode; Transistor Characteristics in Common Emitter mode; RC Coupled amplifier; Oscillators/ Multi vibrators; Integrator/ Differentiator/ Adder/ Subtractor; Operational Amplifier; Introduction to Logic Gates.

**16PHY286 PHYSICS LAB. III 0 0 2 1**

List of Experiments -
Field along the axis of coil; Determine the Cauchy’s constant using Spectrometer; Conservation of Galvanometer to Ammeter; Measurement of Laser beam divergence; Refractive index of transparent bar using diode Laser; Stefan-Boltzmann Constant determination; Emissivity Measurement; Thermal Conductivity of Solids; Natural Convention heat transfer; Moment of inertia of Disc & Ring; Gyroscope couple determination; Hartnell Governor – Speed vs sleeve displacement; Young’s and rigidity modulus of brass by driven vibrations (Dr.R. Srinivasan’s Kit).

**16PHY305 INTERMEDIATE ELECTRODYNAMICS 3 1 0 4**

**Unit 1**
Brief review of Vector Calculus: gradient, divergence, curl and their fundamental theorems; line, surface, and volume integrals, curvilinear coordinates, Dirac delta function, Helmholtz theorem and potentials.
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Unit 2
Electric field: discrete and continuous charge distributions, electric flux, Gauss’s law, divergence of E, applications; Poisson’s and Laplace’s equations; curl of E; Potential and energy of charge distributions; conductors, induced charge; capacitors.

Unit 3
Solution to Laplace’s equation in simple cases; method of images; multipole expansion, dipole moment and field; electric fields in matter: dielectrics, induced dipoles, polarization, bound charges, electric displacement, linear dielectrics.

Unit 4
Magnetic forces and fields: Current densities, calculating magnetic fields from current sources using Biot-Savart’s and Ampere’s laws, curl and divergence of B; magnetic vector potential; magnetic fields in matter: torques and forces on magnetic dipoles, magnetization, bound currents; fields H and B.

Unit 5
Electromagnetic induction & EM waves: Faraday’s law and induced E field, Maxwell’s equations and EM waves in vacuum, momentum and energy density, plane wave solutions.

TEXTBOOKS/ REFERENCES:

16PHY306 RELATIVITY AND MODERN PHYSICS 3 1 0 4

Unit 1
Relativity; Inertial frames and Galilean transformations; postulates of special relativity; length contraction and time dilation; Lorenz transformations; relativistic velocity addition; relativistic momentum and energy, conservation of energy - momentum.

Unit 2
Invitation to Quantum Physics: Specific heat of molecules and solids, Blackbody radiation, Photoelectric & Compton effects, wave-particle duality in light; structure and stability of atoms and the Bohr’s atomic model.

Unit 3
Wave-particle duality in matter, Uncertainty principle, Schrodinger equation, wave-function and its interpretation, stationary states and eigenvalues, expectation values; application to simples systems: Solution to Schrodinger equation for one, two and three dimensional boxes; reflection and transmission at a step potential, tunnelling through a barrier.

Unit 4
Semiclassical quantization and quantum levels of a simple harmonic oscillator and other periodic motion; Statistical Mechanics; Microstates, Macro states, density of states, Boltzmann factor and simple problems.

Unit 5
Statistics of Quantum Systems: distinguishable and indistinguishable particles, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics; some applications, elementary ideas on white dwarfs and neutron stars, super-fluids and superconductors.

TEXTBOOKS/ REFERENCES:
1. Kenneth Krane, Modern Physics, Wiley-India, 2E 2006
3. Bemstein, Fishbane and Gasiorowic, Modern Physics, Pearson, India
5. Eyvind Wichman, Quantum Physics, Berkeley Physics Vol.4, TMH, 2011

15PHY312 INTERMEDIATE MECHANICS 3 1 0 4

Unit 1
Galilean transformation, absolute and relative velocities, inertial and non-inertial frames, rotating frames, centrifugal and coriolis forces; Foucault pendulum.

Unit 2
Conservative forces; contact forces – friction, stress, viscous drag, etc. Pseudo forces and fundamental forces. Mathematical aside: work as a line integral, collisions and conservation laws; potential energy and conservation of energy in gravitational and electric field; stokes theorem, curl, irrotational force fields.

Unit 3
Motion under a centre force, Kepler’s laws, Gravitational law and field, conservative and non-conservative forces, system of particles, centre of mass, equations of motion for centre of mass and relative motion, Angular momentum about centre of mass elastic and inelastic collision, conservation of linear and angular momentum. Variable mass systems.
Unit 4
Fixed axis rotations, rotation and translation, moments of inertia and products of inertia. Principal moments and axes, Behaviour of angular momentum vector.

Unit 5

TEXTBOOKS:
2. H. Goldstein, Charles Poole, John Safko, Classical Mechanics, 3rd Ed, Pearson education, 2002

REFERENCE BOOKS:

PHY315 ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Unit 1

Unit 2
Molecules: energy levels, molecular binding, bonding and anti-bonding orbitals, electronic, vibrational spectroscopy, Heitler-London approximation, Raman Effect and Raman spectroscopy.

Unit 3
Aspects of radiation, Spontaneous and stimulated emissions, masers and lasers, modern spectroscopic techniques and instruments, ESR spectroscopy.

Unit 4
Structure and properties of atomic nucleus, mass and binding energy, nuclear forces, nuclear models, liquid drop model, shell model, quadrupole moment, radioactivity and its applications, nuclear fission and fusion.

Unit 5
Fundamental forces, elementary particles, quarks and leptons, selected topics from Astrophysics.

REFERENCES:
1. Kenneth Krane, Modern Physics, Wiley-India, 2E 2006
2. Eisberg and Resnick, Quantum Physics of Atoms, molecules, solids, Nuclei and particles, Wiley-India, 2E, 2006
3. Arthur Beiser, Concepts of Modern Physics, TMH, 6E, 2006
4. Bernstein, Fishbane and Gasiorowicz, Modern Physics, Pearson, India.

16PHY316 SOLID STATE PHYSICS AND DEVICES

Unit 1
Crystal Structure: Crystal Structures, Bravias lattices and basis, Crustal Plane, Miller Indices, reciprocal lattice; X-ray diffraction and Bragg’s law, diffraction patterns of FCC and BCC structures.

Unit 2
Crystal Binding and Thermal Properties: Binding in molecular solids, Van der Walls forces and Lennard-Jones Potential; Vibrational spectrum (1D); elementary discussion of Einstein and Debye’s theory of specific heat of solids.

Unit 3
Theory of Free Electrons in Metals: Free electron theory, density of states, Fermi energy, elementary discussion of specific heat of electrons; transport in electric magnetic fields, Hall effect.

Unit 4
Band energy Structure of electrons in Crystals: Origin of energy bands, elementary discussion of tight-binding approximation, Fermi surfaces, Brillouin zones; semiclassical motion, acceleration theorem; concept of holes and effective mass.

Unit 5
Semiconductors: Band structure, Intrinsic and extrinsic semiconductors, impunity levels, carrier concentrations, elementary theory of p-n junctions, and transistors; Magnetism: Elementary ideas about dia-para- and ferromagnetism, Langevin’s theory of paramagnetism, Curie’s law.

TEXTBOOKS/REFERENCES:
1. Kittel: Solid State Physics, 8E, Wiley India, 2014
2. S.O. Pillai: Solid State Physics, New Age, 6E, 2010
15PHY331 ASTRONOMY 3 0 0 3

Unit 1

Unit 2
Observational Astronomy
Observing the Universe - The classic Newtonian telescope - The Cassegrain telescope - The Schmidt camera - The Schmidt–Cassegrain telescope - The Maksutov–Cassegrain telescope - Active and adaptive optics - Some significant optical telescopes - Gemini North and South telescopes - The Keck telescopes - The South Africa Large Telescope (SALT) - The Very Large Telescope (VLT) - The Hubble Space Telescope (HST) - The future of optical astronomy - Radio telescopes - The feed and low noise amplifier system - Radio receivers - Telescope designs - Large fixed dishes - Telescope arrays - Very Long Baseline Interferometry (VLBI) - The future of radio astronomy - Observing in other wavebands – Infrared – Sub-millimetre wavelengths - The Spitzer space telescope - Ultraviolet, X-ray and gamma-ray observatories - Observing the universe without using electromagnetic radiation - Cosmic rays - Gravitational waves.

Unit 3

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15PHY341 INTRODUCTION TO NONLINEAR DYNAMICS 3 0 0 3

Unit 1
Introduction: Examples of dynamical systems, discrete and continuous dynamical systems; Maps: 1 - and 2 - dimensional maps; Logistic map, bifurcations in the logistic map, period doubling, fixed points and their stability; Henon map.

Unit 2
Dynamical system described by ODEs: Logistic differential equation, Harmonic Oscillator (simple, damped, driven and damped), Van der Pol oscillator, Duffing oscillator, phase space, phase space trajectories, conservative systems.

Unit 3
Dynamical system theory: Stability of fixed points in 2- Dimensional systems. Stability matrix, types of fixed points. Attractors: 0 -, 1 - and 2-dimensional attractors; strange attractors, basins of attractions.

Unit 4
Origin and measures of chaos: Sensitivity to initial conditions, Lyapunov exponents (LE), LE for one and two dimensional maps; calculation of largest Lyapunov exponent; Fractals: Cantor set, Koch curve, Sierpinski gasket, fractal dimensions.

Unit 5
Time Series: Time delay embedding; Lyapunov exponents from time series; Fractals and Multifractals, Capacity, similarity and correlation dimensions.

REFERENCES:
3. Hilborn, R.C., Chaos and Nonlinear Dynamics, OUP, 2000

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Cosmology – The Origin and Evolution of the Universe - The expansion of the universe - The cosmic microwave background - The hidden universe: dark matter and dark energy - The Drake equation - The Search for Extra Terrestrial Intelligence (SETI) - The future of the universe.

TEXTBOOK:
Introduction to Astronomy and Cosmology, Ian Morison, Wiley (UK), 2008

REFERENCE BOOK:

SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Cosmology – The Origin and Evolution of the Universe - The expansion of the universe - The cosmic microwave background - The hidden universe: dark matter and dark energy - The Drake equation - The Search for Extra Terrestrial Intelligence (SETI) - The future of the universe.

TEXTBOOK:
Introduction to Astronomy and Cosmology, Ian Morison, Wiley (UK), 2008

REFERENCE BOOK:
16PHY342  MATHEMATICAL ASPECTS OF MECHANICS  3 0 0 3

Unit 1
Basics: Art of estimation and approximations, the concept of scaling, dimensional analysis and the nature of functional relationship among physical quantities as imposed by their dimensions (units).

Second order differential equations. Linear and non-linear, with initial conditions and applications to motion in one dimension: changes, rates, graphs of motions; mathematical statements of Newton’s laws; mathematical models of some forces in nature-gravitational, electrostatics, frictional, spring forces and forces that occur in constrained motion.

Unit 2
Inhomogeneous differential equations and applications to forced and damped periodic motions.

First integral invariant and integral of motion: concepts of kinetic energy, work, potential and potential energy, conservation of mechanical energy, and power; phase-space description of motion: Phase-space trajectories, flows, separatrices, and elementary stability theory.

Unit 3
Mathematics of motion of systems of particles: centre of mass coordinates and centre of mass frame; models of contact forces, impulses and collisions; integral invariants and conservation of momentum.

Unit 4
Vector calculus and motion in 2 and 3 dimensions: trajectories in Cartesian, cylindrical and spherical polar coordinates; models of forces in 3 dimensions: vector fields - rotational, irrotational and conservative vector fields, Gauss divergences theorem and fields in a continuous distribution of matter, scalar fields and potentials; symmetry, cyclic coordinates and conservation laws; spherically symmetric force fields; inverse square and linear forces; integral invariants: energy, angular momentum, Laplace-Runge-Lenz vector.

Unit 5

TEXTBOOKS:
1. Kleppner & Kollenkow, Introduction to Mechanics, TMH India
2. Kittel, Berkeley Physics Series Vol 1: Mechanics, 2nd Ed, TMH India

REFERENCES:
2. David Morin, Introduction to Classical Mechanics, CUP, 2009
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

16PHY344 LASERS AND ITS APPLICATIONS 3 0 0 3

Unit 1
Laser - concepts of ordinary and monochromatic light, coherent and incoherent light, interaction of radiation with matter - induced absorption, spontaneous and stimulated emission, metastable state and pumping, active material, Einstein coefficients, population inversion- concepts and discussion of different techniques, resonant cavity.

Unit 2
Gain mechanism, threshold condition for population inversion, emission broadening-line width, Dw FWHM natural emission line width as deduced by quantum mechanics - additional broadening process: collision broadening, broadening due to de-phasing collisions, amorphous crystal broadening. Doppler broadening in laser and broadening in gases due to isotope shifts; Saturation intensity of laser, condition to attain saturation intensity.

Unit 3
Properties of laser – coherency, intensity, directionality, monochromatically and focussibility; Laser transition- role of electrons in laser transitions, 2, 3 and 4 level laser system; Types of Lasers - Ruby, Neodymium, He-Ne, carbon dioxide lasers(principle, working and application), liquid chemical and dye Lasers, semiconductor diode lasers, homo- and hetero-junction lasers, high power semiconductor, diode lasers etc.

Unit 4
Applications - Laser communications: principle, construction, types, modes of propagation, degradation of signal, Analog communication system, digital transmission, fiber optic communication.

Unit 5
Application in other areas: Laser in Medicine - Effects of laser radiation on tissues, surgical uses, ophthalmic uses, laser hazards - biological effects, photo thermal effects, photochemical effects, laser hazards to the eye, to skin, safe exposure; Laser in industry drilling cutting and welding; Holography – principle, types, intensity distribution and applications.

REFERENCES:
1. S O Pillai, Solid State Physics, New Age 6E 2010
Unit 5 Rigid Body Dynamics
Degrees of freedom, rotations - orthogonal transformation and its properties, Euler angles, Euler's theorem, infinitesimal rotations; Rotating frames: rates of change of position and velocity, Coriolis-effect; angular momentum, energy, inertia and Euler equations of motion; torque-free motion of rigid body; symmetrical top.

TEXTBOOKS:

REFERENCES:
2. S.T. Thornton and J.B Marion, Classical Dynamics of Particles and Systems, 5E, Cengage, 2012

15PHY503 MATHEMATICAL PHYSICS I 3 1 0 4

Unit 1 Vector Analysis
Scalar and vector fields, gradient, divergence, curl and Laplacian, vector identities; Line, surface and volume integrals – Gauss, Stokes & Green’s theorems, applications; Orthogonal curvilinear coordinates - expression for gradient, divergence, curl and Laplacian in cylindrical and spherical coordinates.

Unit 2 Linear Algebra & Matrices
Definitions, linear independence of vectors, dimension, inner product, Schwartz inequality, Schmidt’s orthogonalization, orthonormal basis; linear transformations, change of basis; Algebra of matrices, special matrices, eigenvalues and eigenvectors, diagonalization, simultaneous diagonalization of matrices.

Unit 3 Second order differential equations
Ordinary differential equations, singular points, series solutions – Frobenius’ method;

Special Functions: Gamma and Beta functions, Relation between Gamma and Beta functions, Duplication formula, Error function, Bessel’s Functions of different kinds, Integral representations of Bessel’s Functions, Orthogonality of Bessel’s Functions, Modified Bessel’s Functions.

Unit 4 Legendre Polynomials
Recurrence relations, Rodrigue’s formula, orthogonality; associated Legendre polynomials.

Unit 5 Fourier series and function spaces
Examples and applications; sine, cosine and complex series; Basic ideas in function spaces: generalized series of orthogonal functions and polynomials – Legendre, and Bessel series; convergence in the mean, Parseval identity & Bessel inequality, completeness (statement only).

TEXTBOOK:

REFERENCE BOOKS:

15PHY504 QUANTUM MECHANICS I 3 1 0 4

Unit 1 Origins and Schrödinger equation
Summary of experiments & inferences, inadequacy of classical physics, De Broglie’s hypothesis, wave-particle duality; Wave function and Schrödinger equation, probability density, probability current density, Ehrenfest’s theorem, classical - quantum correspondence; expectation values and uncertainties, position, momentum and Hamiltonian operators; wave packets, position-momentum uncertainty principle, classical physics as a limiting case of quantum physics.

Unit 2 Stationary states, energy spectrum and eigenfunctions
Time-independent Schrödinger equation and stationary states; bound states in infinite square well, linear harmonic oscillator – Heisenberg and Schrodinger’s treatments; bound and scattering states in finite square wells and barriers, tunnelling, scattering resonances – Ramsauer-Townsend effect; free particle solutions – Gaussian wave packet; Three dimensional and spherically symmetric potentials: spherical potential well and hydrogen atom, radial wave functions and spherical harmonics, degeneracy of levels.

Unit 3 Postulates and principles
Quantum states, wave functions, and linear vector spaces, bra and ket vectors; Observables and hermitian operators, measurements, eigen values, eigen states, collapse postulate; discrete and continuous spectra; generalized statistical interpretation, expectation values, generalized uncertainty relations; position and momentum representations.

Unit 4 Quantum dynamics
Postulate of time evolution of a quantum state and Schrodinger equation, calculation of evolution of linearly superposed states and expectation values in various potentials, quantum oscillations, two-level systems; motion and spread of free
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Gaussian wave packet; Heisenberg picture of quantum dynamics of observables; energy-time uncertainty relation; introduction to unstable states - decay lifetimes - natural line-widths of spectral lines; coherent-states.

Unit 5 Scattering theory
Incident and scattered waves, scattering amplitude and cross section, Integral equation and Greens functions, Born approximation and its validity, partial wave analysis, optical theorem, calculation of phase shifts, scattering by hard sphere and Coulomb potentials.

TEXTBOOKS:
1. David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005
2. R Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2E 2005

REFERENCE BOOKS:
1. L I Schiff, Quantum Mechanics, TMH, 3E, 2010
3. S Gasiorowicz, Quantum Physics, Wiley India, 2E
4. J J Sakurai, Modern Quantum Mechanics, Pearson, 1E, 1994

15PHY506 COMPUTATIONAL PHYSICS 3 1 0 4

Unit 1 Beginning programming
Description of programming, procedure for writing a program, basic programming elements. MATLAB tutorial: Vectors, matrices, vector operations, loops, plots, executable files, functions, if statements and real-time plotting, data files. Basic concepts: Real and complex numbers, matrices, real functions, errors.

Unit 2 Ordinary Differential Equations
Cauchy problem, Euler methods, convergence analysis, the Crank-Nicolson method, zero-stability, stability on unbounded intervals, high-order methods, predictor-corrector methods, systems of differential equations. Eigenvalues and eigenvectors: power method, convergence analysis, inverse power method with shift, computing the shift, computation of all eigenvalues.

Unit 3 Nonlinear equations

Unit 4 Numerical differentiations and integration
Approximation of function derivatives; numerical integration – midpoint, trapezoidal and Simpson methods; interpolatory quadratures; Simpson adaptive formula. Linear Systems: linear system complexity, LU factorization method, pivoting, accuracy of LU factorization, tridiagonal systems, overdetermined systems, how the MATLAB backlash operator works, iterative methods, Richardson and gradient methods, conjugate gradient method, when to stop iterating, direct methods vs. iterative methods.

Unit 5 Unconstrained optimization
Derivative-free methods, Newton method, descent methods, trust region methods, nonlinear least-squares method; constrained optimization. Approximation of boundary value problems by finite differences and finite elements, finite differences in 2 dimensions, consistency and convergence, heat and wave equations.

TEXTBOOK:

ADDITIONAL REFERENCES:

15PHY511 QUANTUM MECHANICS II 3 1 0 4

Unit 1 Angular momentum, spin and identical particles
Angular momentum, various commutation relations, eigenvalues and eigenfunctions of the angular momentum, maximal set of commuting operators and levels of hydrogen atom; Spin, spin operators, Pauli’s spin matrices, spin in magnetic field; Addition of angular momenta – Clebsch-Gordan Coefficients. Many particle systems, identical particles spin and statistics, symmetric and anti-symmetric wave functions, Pauli’s exclusion principle.

Unit 2 Variational and WKB methods
Variational estimate of ground state energies in simple systems; WKB (semiclassical) approximation of wave functions, tunnelling amplitudes, application to theory of alpha decay, bound states and Bohr-Sommerfeld quantization rule.

Unit 3 Time independent perturbation theory
Non-degenerate and degenerate cases, application to simple systems; Elementary discussion of corrections to energy levels of Hydrogen atom: Zeeman and Stark effects, fine and hyperfine structures.
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Unit 4 Time-dependent perturbation theory
First order correction, constant, sudden, adiabatic and sinusoidal perturbations; transition rates & Fermi golden rule, lifetime of an excited state; selection rules, interaction of an atom with electromagnetic radiation, the Einstein’s A & B coefficients; *Schrodinger, Heisenberg, and Interaction Pictures.

Unit 5 Elements of relativistic quantum mechanics
Klein-Gordon equation for a free particles and particle in electromagnetic (EM) fields; Dirac Hamiltonian and relativistic wave equation, free particle solutions, negative energy states; Dirac equation in EM fields – non-relativistic limit and spin.

TEXTBOOKS:
1. R Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2E 2005
2. David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005
3. L I Schiff, Quantum Mechanics, TMH, 3E, 2010

REFERENCE BOOKS:
1. S Gasiorowicz, Quantum Physics, Wiley India, 2E
2. JJ Sakurai, Modern Quantum Mechanics, Pearson, 1E, 1994
3. David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005

15PHY512 MATHMATICAL PHYSICS II 3 1 0 4

Unit 1 Complex variables
Analytic functions, Cauchy-Riemann conditions, Cauchy's Integral theorem and Integral formula, Laurent expansion, Singularities, Residue theorem, evaluation of integrals.

Unit 2 Complex variables II
Singularities, branch cuts, Riemann surfaces, analytic continuation, principal value, dispersion relations; Integral representations of special functions; saddle point approximation, asymptotic expansions.

Unit 3 Integral Transforms
Laplace transforms, Inversion, convolution theorem, application to initial value problems; Fourier transforms, Inversion, Fourier sine and cosine transforms, convolution theorem, Fourier transforms of derivatives, applications to ODEs.

Unit 4 Partial differential equations
Selected examples of partial differential equations of theoretical physics, solution by the methods of separation of variables, eigenfunction expansions and transform techniques.

TEXTBOOKS:
Arfken & Weber, Mathematical Methods for Physicists, Elsevier Indian Reprint, 6E, 2005

REFERENCE BOOKS:
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Unit 5
Basics ideas on fluctuations and dissipation: Nyquist noise – Brownian motion –
diffusion & dissipation – Einstein’s relation – fluctuations and spatial and time
 correlations – power spectrum & white noise - Langevin theory - fluctuation
dissipation theorem - The Fokker-Planck equation – approach to Maxwell-Boltzmann
distribution.

TEXTBOOKS/ REFERENCES:
1. F Reif, Foundations of Statistical and Thermal Physics, TMH, 1E, 2011
3. Tobochnik and Gould, Thermal and Statistical Physics, Princeton University Press, 2010
5. R.K. Pathria, Statistical Mechanics, 3E, Elsevier India.

15PHY514   ADVANCED ELECTRODYNAMICS   3104

Unit 1 Electrostatics
Gauss’ law and its applications; Laplace and Poisson equations, boundary value
problems – basics, multipoles; macroscopic electrostatics in dielectrics.

Unit 2 Magnetostatics
Biot-Savart’s law, Ampère’s theorem, vector potential, magnetic multipole expansion,
macroscopic magnetostatics in matter.

Unit 3 Changing Fields
Electromagnetic induction, electrodynamics in free space and linear isotropic media,
Maxwell’s equations; boundary conditions on fields at interfaces; Poynting vector,
conservations laws; gauge transformation and gauge invariance.

Unit 4 Electromagnetic Waves
Propagation in free space, dielectrics, conductors, and plasma; transmission lines
and wave guides; reflection, refraction, Fresnel’s laws; states of polarization.

Unit 5
Radiation from moving charges, retarded potentials; dipole radiation; power radiated;
Relativity of electromagnetic fields; Lorentz invariance of Maxwell’s equations,
transformation of electromagnetic fields.

TEXTBOOKS/ REFERENCES:

15PHY515   EXPERIMENTAL TECHNIQUES   3104

Unit 1 Data analysis
Date interpretation and analysis; Precision and accuracy, error analysis, propagation
of error, least squares fitting, linear and non-linear curve fitting, chi-square test.

Unit 2 Transducers
Temperature, pressure/vacuum, magnetic field, vibration, optical, and particle
detectors.

Unit 3 Electronics
Nyquist noise in electronic measurements, filtering and noise reduction, shielding
and grouping; Fourier transforms; lock-in detector, box-car integrator, modulation
techniques; Data acquisition through computers.

Unit 4 Spectroscopic techniques I
ESR, NMR, FTNMR, X-ray diffraction (Power, Laue), SEM TEM, AFM.

Unit 5 Spectroscopic techniques II
IR, FTIR, Raman.

TEXTBOOKS:
1. P.R. Bevington, D.K. Robinson, Data reduction and Error Analysis for the Physical Sciences,
2. N.C. Barford, Experimental Measurements: Precision, Error, and Truth, Addison-Wesley (1968)
5. T. Pradeep, NANO: The Essentials: Understanding Nanoscience and Nanotechnology, Mcgraw
   Hill India (2007)

15PHY531   ANTENNAS AND WAVE PROPAGATION   3003

Unit 1 Review of electromagnetic theory
Vector potential, Solution of wave equation, retarded case, Hertzian dipole. Antenna
characteristics: Radiation pattern, Beam solid angle, Directivity, Gain, Input
impedance, Polarization, Bandwidth, Reciprocity, Equivalence of Radiation patterns,
Equivalence of Impedances, Effective aperture, Vector effective length, Antenna
temperature.
Unit 2 Wire antennas

Unit 3 Aperture Antennas

Unit 4 Special Antennas
Long wire, V and Rhombic Antenna, Yagi-Uda Antenna, Turnstile Antenna, Helical Antenna - Axial mode helix, Normal mode helix, Biconical Antenna, Logperiodic Dipole Array, Spiral Antenna, Microstrip Patch Antennas. Antenna Measurements: Radiation Pattern measurement, Gain and Directivity Measurements

Unit 5

TEXTBOOKS:

REFERENCE BOOKS:

PHYS533 BIOPHOTONICS 3 0 0 3

Unit 1

Unit 2

Unit 3
Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, biosensors based on fibre optics planar waveguides, evanescent waves, interferometry and surface Plasmon resonance. Flow cytometry: Basics, fluorochromes for flow cytometry, DNA analysis.

Unit 4

Unit 5

TEXTS:
Unit 1 Introduction

Unit 2 Spectroscopy
UV spectroscopy, circular dichroism, Fluorescence spectroscopy, IR, Raman and Electron spin spectroscopy, NMR spectroscopy.

Unit 3 Molecular Modeling & Macromolecular Structure
Building the structure of H2O2, nucleic acid structure, monomers, polymers, double helical structure of DNA, Polymorphism and nanostructure of DNA, structure of RNA, protein structure: amino acids, virus structure.

Unit 4 Energy Pathways in Biology
Free energy, couple reactions, group transfer potential, pyridine nucleotides, photosynthesis, energy conversion pathways, membrane transport. Biomechanics: strained muscles, mechanical properties of muscles, cardiovascular system.

Unit 5 Neurobiophysics

TEXTBOOKS:

Unit 2 Cloud development and precipitation

Unit 3 Air masses, fronts, and mid-latitude cyclones. Weather forecasting Acquisition of weather information, forecasting methods and tools, forecasting using surface charts. Thunderstorms: ordinary (air-mass) thunderstorms, mesoscale convective complexes, floods and flash floods, distribution of thunderstorms, lightning and thunder. Tornadoes: severe weather and Doppler radar, waterspouts.

Unit 4 Hurricanes (cyclones, typhoons)
Tropical weather; anatomy, formation, dissipation and naming of hurricanes. Air pollution: a brief history, types and sources, factors that affect air pollution, the urban environment, acid deposition. Global climate: climatic classification; global pattern of climate.

Unit 5 Climate change
Possible causes; carbon dioxide, the greenhouse effect, and recent global warming. Light, color, and atmospheric optics: white and colors, white clouds and scattered light; blue skies and hazy days, red suns and blue moons; twinkling, twilight, and the green flash; the mirage; halos, sundogs, and sun pillars; rainbows; coronas and cloud iridescence.

TEXTBOOK:

REFERENCE:

Unit 1 Earth’s atmosphere
Overview and vertical structure. Warming the earth and the atmosphere: temperature and heat transfer; absorption, emission, and equilibrium; incoming solar energy, Air temperature: daily variations, controls, data, human comfort, measurement. Humidity, condensation, and clouds: circulation of water in the atmosphere; evaporation, condensation, and saturation; dew and frost; fog.

TEXTBOOK:
15PHY534  3003

Unit 1 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards
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SYLLABI
decay; physical properties & groups of minerals; silicates, important nonsilicate minerals, resources. Igneous rocks: magma, igneous processes, compositions & textures; naming igneous rocks; origin and evolution of magma, intrusive igneous activity, mineral resources and igneous processes.

Unit 2 Volcanoes and volcanic hazards
Materials extruded, structures and eruptive styles, composite cones and other volcanic landforms, plate tectonics and volcanic activity. Weathering and soils: earth's external processes; mechanical & chemical weathering, rates; soils, controls of formation, profile, classification, human impact, erosion, weathering and ore deposits. Sedimentary rocks: the importance and origins of sedimentary rocks; detrital & chemical sedimentary rocks, coal, converting sediment into sedimentary rock; classification & structures, nonmetallic mineral & energy resources. Metamorphism and metamorphic rocks: metamorphic textures, common metamorphic rocks, metamorphic environments & zones.

Unit 3 Mass wasting

Unit 4 Shorelines
Coastal zone, waves & erosion, sand movement, shoreline features & stabilization; erosion problems along U.S. coasts, hurricanes, coastal classification, tides. Earthquakes and earth’s interior: faults, seismology, locating the source of an earthquake, measuring intensity, belts and plate boundaries, destruction, damage east of the Rocky Mountains, earthquake prediction, earth’s interior. Plate tectonics: continental drift, divergent boundaries, convergent boundaries, transform fault boundaries, testing the plate tectonics model, the breakup of Pangaea, measuring plate motion, what drives plate motions, plate tectonics in the future.

Unit 5 Origin and evolution of the ocean floor
Continental margins, features of deep-ocean basins, anatomy of oceanic ridge, oceanic ridges and seafloor spreading, nature of oceanic crust, continental rifting, destruction of oceanic lithosphere. Crustal deformation and mountain building: structures formed by ductile & brittle deformation, mountain building at subduction zones, collisional mountain belts, fault-block mountains, vertical movements of the crust. Geologic time: time scales, relative dating, correlation of rock layers; dating with radioactivity, the geologic time scale, difficulties in dating. Earth’s evolution: birth of a planet, origin of the atmosphere and oceans, Precambrian (formation of continents); Phanerzoic (formation of modern continents & earth’s first life); Paleozoic (life explodes); the Mesozoic (dinosaurs); Cenozoic era (mammals). Global climate change: climate & geology, climate system, detecting change; atmospheric basics & heating the atmosphere; natural & human causes; carbon dioxide, trace gases, and climate change; climate-feedback mechanisms, aerosols, some possible consequences.

TEXTBOOK:

REFERENCE:

15PHY537 FIBER OPTIC SENSORS AND APPLICATIONS 3 0 0 3

Unit 1

Unit 2
In-fiber Bragg grating based sensors – sensing principles – temperature and strain sensing, integration techniques, cross sensitivity, FBG multiplexing techniques. Long period fiber grating sensors-temperature and stain sensing, refractive index sensing, optical load sensors and optical bend sensors.

Unit 3
Interferometric sensors, Mach-Zehnder & Michelson interferometric sensors, Theory - expression for fringe visibility, Fabry-perot fiber optic sensors – theory and configurations, optical integration methods and multiplication techniques, application – temperature, pressure and strain measurements, encoded sensors.
Syllabi 5-yr Integrated M Sc Maths/Physics 2016 admissions onwards

Unit 4

Unit 5
Biomedical sensors, sensors for physical parameters, pressure, temperature, blood flow, humidity and radiation loss, sensors for chemical parameters, pH, oxygen, carbon, dioxide, spectral sensors. Distributed fiber optic sensors – intrinsic distributed fiber optic sensor – optical time domain reflectometry based Rayleigh scattering – optical time domain reflectometry based Raman scattering – optical time domain reflectometry – quasi – distributed fiber optic sensors. An overview on the optical fiber sensors in nuclear power industry, fly-by light aircraft, oil field services, civil and electrical engineering, industrial and environmental monitoring.

Textbooks:
1. Francis T.S. Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York, 2002

References:
1. Jose Miguel Lopez-Higuera (Ed), Handbook of optical fiber sensing technology, John Wiley and Sons Ltd., 2001
2. Eric Udd (Ed), Fiber optic sensors: An introduction for engineers and scientists, John Wiley and Sons Ltd., 1991

15 PHY538 FIBER OPTICS AND TECHNOLOGY 3 0 0 3

Unit 1 Classification of fibers
Based on refractive index profiles, modes guided applications and materials. Fibers for specific applications: polarization maintaining fibers (PMF), dispersion shifted and dispersion flattened fibers, doped fibers. Photonic crystal fibers, holly fibers.

Fiber specifications: Numerical aperture of SI and GI fibers, Fractional refractive index difference, V – parameter, Cut off wavelength, dispersion parameter, bandwidth, rise time and Non linearity coefficient.

Textbooks:
3. John M senior, Optical fiber communications, PHI, 1992

References:
15PHY539 \hspace{0.5cm} \textbf{NANOPHOTONICS} \hspace{0.5cm} 3 \hspace{0.2cm} 0 \hspace{0.2cm} 0 \hspace{0.2cm} 3

\textbf{Unit 1}
Introduction to nanoscale interaction of photons and electrons. Near field interaction and microscopy - near field optics and microscopy - single molecule spectroscopy - nonlinear optical process.

\textbf{Unit 2}
Materials for nanophotonics - quantum confinement - optical properties with examples - dielectric confinement - super lattices - organic quantum confined structures.

\textbf{Unit 3}
Plasmonics - metallic nanoparticles and nanorods - metallic nanoshells - local field enhancement - plasmonic wave guiding - applications of metallic nanostructures.

\textbf{Unit 4}

Unit 5

\textbf{TEXTBOOKS:}
1. Paras N. Prasad, Nanophotonics, Wiley Interscience, 2004
2. Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge University Press, 2006

\textbf{REFERENCES:}

15PHY543 \hspace{0.5cm} \textbf{PHYSICS OF COLD ATOMS AND IONS} \hspace{0.5cm} 3 \hspace{0.2cm} 0 \hspace{0.2cm} 0 \hspace{0.2cm} 3

\textbf{Unit 1}
Two level atom in a radiation field, Laser light pressure, Atoms in motion, Travelling wave and standing wave - Multilevel atoms, Alkali metal atoms, metastable noble gas atoms, Polarization and interference, Angular momentum and selection rules and Optical transitions in Multilevel atoms.

\textbf{Unit 2}

\textbf{Unit 3}
Optical Molasses: Introduction, Low-Intensity Theory for a Two-Level Atom in One
ARTS AND SCIENCES

2016 admissions onwards

5-yr Integrated M Sc Maths/ Physics

SYLLABI

Dimension, Atomic Beam Collimation, Low-Intensity Case, Experiments in One and Two Dimensions, Experiments in Three-Dimensional Optical Molasses.

Unit 4
Cooling below the Doppler limit - Magnetic trapping of neutral atoms. Optical Traps – Magneto optical traps - Evaporative cooling.

Unit 5
Applications to atom mirrors, lenses, atomic fountain, nano fabrication, atomic clocks and nonlinear optics - Optical lattices - Bose Einstein condensation Entangled states and quantum computing.

TEXTBOOKS:

15PHY544 QUANTUM ELECTRODYNAMICS 3 0 0 3

Unit 1 Lorentz Covariance of the Dirac Equation

Unit 2 The Foldy-Wouthuysen Transformation

Unit 3 General Formulation of the Quantum Field Theory

Unit 4 Second Quantization of the Electromagnetic Field

SYLLABI

5-yr Integrated M Sc Maths/ Physics

Unit 5 Quantization of the Electromagnetic Field
Introduction, Quantization, Covariance of the Quantization Procedure, Momentum Expansions, Spin of the Photon, The Feynman Propagator for Transverse Photons.

TEXTBOOKS:
1. Bjorken & Drell: “Relativistic Quantum Mechanics”
2. Bjorken & Drell: “Relativistic Quantum Fields”

REFERENCE BOOKS:
1. Schweber, Bethe and Hoffmann: Mesons and Fields
2. Sakurai: Advanced Quantum Mechanics
3. Lee: Particle Physics and Introduction to Field Theory

15PHY545 QUANTUM OPTICS 3 0 0 3

Unit 1
Correlation functions of light waves. Spectral representation of mutual coherence function.

Calculation of mutual intensity and degree of coherence, propagation of mutual intensity.

Rigorous theory of partial coherence. Coherency matrix of a quasi monochromatic plane wave. Stochastic description of light and higher order coherence effects.

Unit 2
Quantization of the radiation field, Quantum mechanical harmonic oscillator, the zero point energy, states of the quantized radiation field, single mode number states and phase states, coherent photon states.

Unit 3

Unit 4
Statistical optics of photons: Photon coherence properties, photon counting, photon distribution for coherent and chaotic light, quantum mechanical photon counting distribution.

Unit 5
REFERENCES:

SYLLABI
5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

15PHY546
THIN FILM TECHNOLOGY 3 0 0 3

Unit 1 Preparation methods
Physical methods: thermal evaporation, cathodic sputtering, Molecular beam epitaxy and laser ablation methods. Chemical methods: electrolytic deposition, chemical vapour deposition.

Unit 2 Thickness measurement and Characterisation
Electrical, mechanical, optical interference, microbalance, quartz crystal methods. Analytical techniques of characterization: X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy.

Unit 3 Growth and structure of films
General features - Nucleation theories - Effect of electron bombardment on film structure - Post nucleation growth - Epitaxial film growth - Structural defects.

Unit 4 Properties of films

Unit 5 Magnetism of films
Molecular field theory - Spin wave theory - Anisotropy in magnetic films-Domains in films - Applications of magnetic films.

TEXTBOOKS:

SYLLABI
5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

15PHY547
OPTICS 3 1 0 4

Unit 1 Review of basics
Wave motion in 1D: harmonic waves, phase and phase velocity, superposition principle, complex representation; Wave equation: plane, cylindrical and spherical waves and wave-fronts; Maxwell equations, EM waves, photons, and light, energy and momentum transport, radiation pressure; Propagation of light in matter, Rayleigh scattering, origin of refractive index.

Unit 2 Review of (a selection of topics in) geometric optics
Reflection, refraction, total internal reflection, beam splitting; Lenses, Stops, Mirrors, Prisms, Lens & Optical systems; Introduction to wave front shaping, analytical ray tracing, aberrations; Wave optics: superposition of waves having same and different frequencies, group and phase velocities; anharmonic periodic and aperiodic waves; pulses and wave packets, natural linewidth, coherence time and length.

Unit 3 Polarization
Linear, elliptical and circular polarizations; Dichroism, Birefringence, polarization by scattering and reflection; Retarders; Circular polarizers; Basics of optical activity, induced optical effects, modulators, and liquid crystals; Mathematical theory of polarization: polarization ellipse, Poincare sphere, Stokes parameters, Jones vectors & matrices.

Unit 4 Interference
Introduction, conditions for interference, wavefront splitting and amplitude splitting interferometers, types and location of interference fringes, multiple beam interference, interferometry, applications; Diffraction: Introduction, Fraunhoffer and Fresnel diffraction, Kirchoff's scalar diffraction theory; diffraction by circular aperture, single, double and multiple slits, diffraction grating, resolving power.

Unit 5 Fourier Optics
Fourier transforms, optical applications; Basics of Coherence Theory - introduction, visibility, mutual coherence function, degree of coherence, stellar interferometry; Basic ideas on nonlinear optics: harmonic generation, optical rectification, frequency mixing, self-focusing.
TEXTBOOKS/ REFERENCES:
1. E. Hecht and A.R. Ganesan, Optics, 4E, Pearson, 2008 (Prescribed)
3. J. Peatross & M. Ware, Physics of Light and Optics (Available online at: http://optics.byu.edu/ BYUOpticsBook_2013.pdf)

15PHY548 FUNDAMENTALS OF PLASMA PHYSICS 3 0 0 3
(Pre-requisites: 16PHY305 Intermediate Electrodynamics and 15PHY514 Advanced Electrodynamics)

Unit 1
Introduction – Spatial scale of an unmagnetized plasma – Debye Length, time scale
- plasma period, gyroradius and gyrofrequency of magnetized plasma, single particle
motion in prescribed fields - ExB, grad-B, Curvature and polarization drifts, magnetic
moment, adiabatic invariants of particle motion, magnetic mirror.

Unit 2
Kinetic theory of plasmas, Boltzmann equation, Maxwell-Boltzmann distribution,
Vlasov description of collisionless plasmas, Moments of the Boltzmann equation,
Systems of macroscopic equations: Cold and Warm plasma models.

Unit 3
Plasmas as fluids - Two fluid description, equation of motion, Drifts perpendicular
to B, parallel pressure balance.

Unit 4
Single fluid theory of plasmas: Magneto hydrodynamics (Hydromagnetic, MHD).

Unit 5
Introduction to waves in plasmas, waves in cold magnetized and unmagnetized
plasma, Fourier representation, Dispersion relation, Waves in hot (magnetized)
plasmas, Landau Damping, CMA diagram, Instabilities, MHD Waves, Alfvén Waves,
MHD discontinuities.

TEXTBOOKS/ REFERENCES:
1. Umran S. Inan & Marek Golowski, Principles of Plasma Physics for Engineers and Scientists,
Cambridge, 2011

15PHY550 APPLIED QUANTUM MECHANICS AND
MATERIAL MODELING 3 0 0 3

Unit 1
Hückel molecular orbital theory – approximations - The Born-Oppenheimer,
independent particle, Pi-electron-expectation energy and Hückel M.O., Hückel
Molecular Orbital and symmetry the extended Hückel method.

Unit 2
Hartree–Fock theory - Bosons and Fermions, Slater determinant - energy calculation
from STO function, energy calculation of multi-electron systems. Gaussian type
SYLLABI 5-yr Integrated M.Sc. Maths/Physics 2016 admissions onwards

Unit 3
Basis sets: classification - contracted Gaussian type orbitals (CGTO), double- and triple-zeta, split-valence, polarized, double, triple-zeta, split-valence and polarized basis sets. Gaussian type and contracted Gaussian orbitals. Truncation and basis set superposition errors.

Unit 4

Unit 5
Density functional theory - Electron density, Pair density, Functional, Hohenberg and Kohn (H.K.) theorems, Kohn and Sham Method and its Implementations common functionals and potentials.

Applications of modeling and simulation – Transition states, charge, electron density, population analysis.

REFERENCES/TEXTBOOKS:

15PHY551 EPISTEMOLOGICAL FOUNDATIONS OF QUANTUM MECHANICS

Unit 1
Historical & epistemological Perspective: Quick review of the failure of classical mechanics and origin of QM: Planck-Einstein, Bohr atom, de Broglie, Heisenberg's uncertainty principle, Experimental verifications – wave-particle duality and Young's double-slit experiment, polarization experiments, Schrödinger equation - particle in a box, tunnel effect.

Unit 2
Dirac's Ket and Bra formulations and Hilbert space representation, Mach-Zhender type interferometers; Reality and trajectory of a particle, Fermions and Bosons, Pauli Exclusion Principle and indistinguishability, symmetry; State-vector reduction and measurement problem, decoherence.

Unit 3

Unit 4
Various interpretations of QM: Statistical, Copenhagen, Bohm’s formulation, Transactional, Wheeler’s Participatory Universe, Many World, Transactional Interpretation, Consciousness interpretation – Philosophical implications.

Unit 5
Modern applications of quantum entanglement: Quantum teleportation, Quantum Erasing, Introduction to Quantum cryptography and Quantum Computing, dense coding, Quantum Information.

REFERENCE BOOKS:
Since the subject is rather unconventional, there are no affordable, tailor-made text book is available. Hence the following reference books are suggested for reading. Separate additional lecture notes will be provided.

SUGGESTED READING:

15PHY552 INTRODUCTION TO FOURIER OPTICS

(Pre-requisite: 15PHY547 Optics)

Unit 1 Analytic Fourier Theory Review
Analysis of two dimensional signals and systems – Fourier analysis in 2D, Local Spatial Frequency and Spatial Frequency localization, Linear systems, Two dimensional sampling.
**SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards**

**Unit 2 Scalar diffraction & propagation solutions, Simulations**
Scalar diffraction theory – Introduction, vector to scalar theory, mathematical preliminaries, Kirchoff formulation of diffraction by a planar screen, Rayleigh-Sommerfeld formulation, Huygen-Fresnel principle, Angular spectrum of plane waves.

**Unit 3 Diffraction**
Fresnel and Fraunhofer diffraction – Background, Fresnel and Fraunhofer approximations, Examples of Fraunhofer diffraction patterns and Fresnel diffraction calculations.

**Unit 4 Transmittance functions, Lenses & Gratings**
Wave optics analysis of coherent optical systems – thin lens as a phase transformation, Fourier transforming properties of lenses, image formation: monochromatic illumination.

**Unit 5 Imaging and diffraction limited imaging, wavefront aberrations and modulation, simulations**
Frequency analysis of optical imaging systems – generalized treatment, frequency response for diffraction limited coherent and incoherent imaging; Aberrations and their effects on frequency response, comparisons of coherent and incoherent imaging, resolution beyond classical diffraction limit; Wavefront modulation – incoherent image and coherent optical information processing systems, applications.

**TEXTBOOK/ REFERENCES:**
2. E.G. Steward, Fourier Optics – An Introduction, Dover, 2004

**15PHY533 INTRODUCTION TO NANOPHYSICS AND APPLICATIONS 3 0 3**

**Unit 1 Introduction**
Relation of nano to other sciences - chemistry, biology, astronomy, geology, nano in nature.

**Unit 2 Properties of nanomaterials**
Size effect, particle’s size, shape, and density, melting point, surface tension, wettability, surface area and pore, composite structure, crystal structure, surface characteristics; mechanical, electrical, properties, and optical properties.

**Unit 3 Synthesis of nanoparticles**
Classification of fabrication methods – top-to-bottom and bottom-to-top approaches, physical and chemical methods of preparation: CVD, controlled precipitation, sol-gel method, PLD etc; Confinement of particles - low dimensional structures - quantum wells, wires and dots.

**Unit 4 Characterisation of nanoparticles**
X-Ray diffraction, examples of XRD, Debye-Scherrer formula; FTIR: principle, methodologies and accessories; SEM: basics and primary mode of operation, applications; TEM: basic principles; STM: basic principles and instrumentation; AFM: basics, modes of operation and applications; Photoluminescence: basic principles.

**Unit 5 Application of nanophysics**
Carbon nanostructures: Fullerene, CNTs and their applications; MEMS and NEMS devices; Quantum Cascade Lasers, Smart materials, GMR and Spintronic, multiferroics.

**REFERENCES:**
4. S.V. Gaponenko, PL Knight & A. Miller, Optical Properties of Semiconductor Nanocrystals, CUP. 1E, 2005
5. T Pradeep, Nano: The Essentials, TMH, 1E, 2007

**15PHYS54 OPTOELECTRONICS 3 0 3**

**Unit 1**
Electronic and Optical processes in semiconductors.

**Unit 2**
P-n junction theory. Light emitting diodes.

**Unit 3**
Laser diodes: structures, properties and operating principles.

**Unit 4**
Photodetectors, Solar cells; Optoelectronic modulators and switching devices.

**Unit 5**
Systems needs and new device challenges.

**TEXTBOOKS/ REFERENCES:**

15PHY555 PHYSICS OF THE ATMOSPHERE 3 0 0 3

Unit 1

Unit 2

Atmospheric radiation – Basic physical concepts, Radiative transfer equation, basic spectroscopy of molecules, Transmittance, Absorption by atmospheric gases, Heating rates, Greenhouse effect revisited, Simple scattering model.

Unit 3
Basic fluid dynamics – Mass conservation, material derivative, alternative form of continuity equation, equation of state for the atmosphere, Navier-Stokes equation, Rotating frames of reference, equations of motion in coordinate form, geostrophic and hydrostatic approximation, Pressure coordinates and geopotential, Thermodynamic energy equation; Atmospheric fluid dynamics – vorticity and potential vorticity, Boussinesq approximation, Quasi-geostrophic motion, Gravity waves, Rossby waves, Boundary layers, Instability.

Unit 4
Stratospheric chemistry – Thermodynamics and chemical reactions, Chemical kinetics, Bimolecular reactions, Photo-dissociation, Stratospheric ozone, Transport of chemicals, Antarctic ozone hole.

Atmospheric remote sounding – Observations, remote sounding from space and ground; Atmospheric modeling – Hierarchy of models, Numerical methods, Uses of complex numerical models, Lab models.

Unit 5
Climate change – Introduction, energy balance model, some solutions of the linearized energy balance model, Climatic feedbacks, Radiative forcing due to increase in Carbon dioxide.

Projects based on Modules 3, 4 and 5 (Reading a journal paper & reproducing calculations, Numerical modeling and/ or data analyses)

TEXTBOOKS/REFERENCES:
3. Holton JR: An introduction to Dynamic Meteorology, 4E, AP, 2004

15PHY556 PYTHON FOR SCIENTIFIC COMPUTING 3 0 0 3

(Prerequisite: 15PHY506 Computational Physics and 15PHY582 Simulation Lab.)

Unit 1
Installing and running the GNU/ Linux OS, BASH shell environment.

Unit 2
Programming in Python – Introduction, Ipython, NumPy library, Matplotlib and others, SciPy and numerical methods, SymPy, Pandas and data frame, GUI, Extending Python and FORTRAN and sysops, Building Python applications and packaging.

Unit 3
Storing data, HDF5, Basic data structures in Physics.

Unit 4
Any other topic(s) of interest, if time permits. Physics projects based on student interest.

TEXTBOOKS/REFERENCES:
The course will make use of various excellent web resources and text books. All such information will be made available on the course site.

15PHY557 ASTROPHYSICS AND COSMOLOGY 3 0 0 3

Unit 1
Stellar dynamics, types of forces on a star in the stellar system, Tidal radii, star-star encounter, time of relaxation determination of time of relaxation, application to Galaxy & star cluster.
Masses of double galaxies, Masses of cluster of galaxies by virial theorem observational determination of masses, clusters of galaxies, Missing mass problem.

Unit 2
Cosmology, cosmological principle, Newtonian cosmology, deceleration parameters critical density, Robertson walker equation and its properties, solution of Robertson-Walker equations. Einstein field equation in cosmology, Energy tensor of Universe, solution of Friedman’s equation, Einstein de-sitter model, open model, particle horizon, Event horizon.

Unit 3
The formation of structures in the Universe: Jean’s equation derivation from fluid dynamics and General relativity; evolution of Jean mass, Growth in the Post recombination era; Einstein-do Sitter model; closed model; open model; observation constraints; small angle anisotropy, horizon problem, the scale – invariant spectrum, Hierarchy of structures, Age distribution.

Unit 5
Thermal History of the Universe, Temperature red shift relation, distribution in the early Universe, relativistic and non-relativistic limits, decoupling of matter and radiation, Cosmic microwave background radiation (CMBR), isotropy and anisotropy of CMBR.

TEXT AND REFERENCE BOOKS:
1. Introduction to Cosmology By J.V.Narlikar
2. Structure Formation in the Universe by T. Padmanabhan, Cambridge University
3. Stellar Dynamics by S.Chandersakher
4. Stellar Evolution by Kippenhahn

15PHY558 NONLINEAR DYNAMICS AND CHAOS 3 0 0 3

Unit 1 Introduction, Phase Space, and Phase Portraits
Linear systems and their classification; Existence and uniqueness of solutions; Fixed points and linearization; Stability of equilibria; Pendulum and Duffing oscillator, Lindstedt’s method; Conservative and reversible systems.

Unit 2 Limit Cycles
The van der Pol oscillator, Method of Averaging; Relaxation oscillators; Weakly nonlinear oscillators; Forced Duffing oscillator, Method of Multiple Scales; Forced van der Pol oscillator, Entrainment; Mathieu’s equation, Floquet Theory, Harmonic Balance.

15PHY559 PHYSICS OF OPTOELECTRONIC DEVICES 3 0 0 3

Unit 1 Introduction
Semiconductor materials; Crystal lattices; Bulk Crystal growth, epitaxial growth.

Unit 2 Energy bands and Charge carriers in Semiconductors
Direct and indirect semiconductors; variation of Energy bands with alloy composition. Charge carriers in semi-conductors-electrons, holes, effective mass; intrinsic and extrinsic materials. Drift of carriers in electric and magnetic fields.

Unit 3 Excess carriers in Semiconductors
Unit 4 Optoelectronic Devices
Principle of operation and characteristics; Light emitting diodes, lasers, photo detectors, solar cells. Relevance of III-V and IV-VI material-systems in optoelectronic devices.

Unit 5 Integrated Optics
Optical waveguides - passive, electro-optical; optical modulators and switches; optical storage devices.

TEXTBOOK:

REFERENCE BOOKS:

A selection of experiments from the following list:
Michelson’s interferometer; Ultrasonic interferometer; Photoelectric effect; Fourier Analysis Kit; Four Probe and measurement of band gap of Ge; Hall effect of doped semiconductors; Magneto-resistance of Ge; Quincke’s tube experiment for measurement of magnetic susceptibility; Electron-spin resonance.

Experiments from Dr. R.Srinivasan’s kit:
Calibration of Cu-Constantan thermocouples as temperature sensors, Stefan's constant of radiation, Thermal and electrical conductivities of Cu and its Lorenz number, Thermal conductivity of a poor conductor, Thermal diffusivity of brass; Temperature coefficient of resistance of Cu, Energy band gap of Si, Determination of k/e using a transistor; Dielectric constant of a non-polar liquid, Dipole moment of an organic molecule – acetone, Verification of Curie-Weiss law for a ferroelectric material – temperature dependence of a ceramic capacitor; Magnetic hysteresis and B-H curve of a ferromagnetic material; Principle of phase sensitive detection and the calibration of a lock-in amplifier, Measurement of mutual inductance and low resistance with a lock-in amplifier; Experiments in non-linear dynamics: Chua circuit, Feigenbaum circuit for period doubling.

REFERENCES:
2. Other Lab manuals and Handouts.
15PHY602 Condensed Matter Physics 3 1 0 4

Unit 1 Basic Concepts
Review of free electron theory of metals, thermal and electrical transport properties; inadequacies; Brief review of crystal structure & symmetry, crystal planes, reciprocal lattices and X-ray diffraction pattern, Bragg planes & Brillouin zones.

Unit 2 Electrons in periodic potentials
Bloch theorem, band energy spectrum; nearly free electron and Tight binding models, Fermi surface, energy spectrum of selected solids.

Unit 3 Electron transport
Semiclassical dynamics in electric and magnetic fields, band insulators and metals, Bloch oscillations, effective mass and concepts of holes; Hall effect and magneto-resistance; Landau levels, de-Hass van Alfen oscillations; quantum Hall effect.

Unit 4 Semiconductors
Energy band structure & parameters – direct and indirect energy gaps and effective masses, photo-absorption, cyclotron resonance; intrinsic and extrinsic semiconductors, equilibrium carrier concentrations; p-n junctions, Schottky-barrier.

Superconductivity: persistent currents, Meissner effect, London's equations, introduction to BCS theory and its predictions, Ginzburg-Landau theory, flux quantization, Josephson effects, SQUID.

Unit 5 Magnetism in solids
Dia- and paramagnetism, quenching of orbital angular momentum, Pauli paramagnetism and Landau diamagnetism in metals and semiconductors; exchange interactions, Heisenberg model, ferro- and anti-ferromagnetism.

TEXTBOOKS/ REFERENCES:
2. 88ach and Luth, Sol State Physics, Springer India, 3E, 2002.

15PHY603 Nuclear and Particle Physics 3 1 0 4

Unit 1 Nuclear Structure
Basic nuclear properties, Rutherford’s scattering, charge distribution, spin and parity, magnetic moment, binding energy – stable & unstable nuclei, packing fraction; liquid drop model – semi empirical mass & binding energy formula, mass parabolas, shell model – validity & limitations.
SYLLABI

**5-yr Integrated M Sc Maths/ Physics**

**2016 admissions onwards**

**15PHY604 ADVANCED ELECTRONICS** 3 1 0 4

**Unit 1**
Optoelectronic devices, solar cells, photodetectors, and LEDs.

**Unit 2**
Digital technique and applications: registers, counters, comparators and similar circuits.

**Unit 3**
Introduction to operational amplifiers, concept of negative feedback and virtual short, analysis of simple operational amplifier circuits, frequency response of amplifiers, feedback topologies and analysis of discrete transistor amplifiers; signal conditioning and recovery in measurement and control systems.

**Unit 4**
Active filters and switched capacitor filters; Wave form generators, A/D instruction set, programmable peripheral devices.

**Unit 5**
Introduction to 8086 microprocessor and its instruction set Assembly level programming, Introduction to microcontrollers and embedded systems.

**REFERENCES:**
2. John D. Ryder, Electronic Fundamentals and applications PHI, 1999
3. Gayakwad, Operational Amplifiers & Linear Integrated Circuits, Pearson India, 201
5. Gaonkar, Microprocessor Architecture Programming and Applications with the 8085, penram international, 1999

**15PHY682 ADVANCED ELECTRONICS LAB.** 0 0 6 2

Design and study of CE amplifier with and without feedback, two stage amplifier, Power amplifier, Differential amplifier, Voltage regulated power supplies with Zener diodes and transistors. Design of basic DL, TI and TTL logic gates, RS and JK flip flops using NOR-NAND gates, Schmitt trigger using op-amp, Uses of IC 741, Phase shift oscillator, 555 timer, three terminal IC voltage regulator, Familiarization of 8085 kit and programming, A/D and D/A converters, control of stepper motor.

**TEXTBOOK/ REFERENCES:**

**SYLLABI**

**5-yr Integrated M Sc Maths/ Physics**

**2016 admissions onwards**

**15PHY691 SEMINAR B** 0 0 2 1

A topic from selection of topics from different branches of Physics with the assistance of the instructor of the course may be chosen for a 30-45 minutes presentation. Topics relevant to the final semester project are encouraged.

**15PHY696 PROJECT** 10 cr

The aim of the project work is to give more detailed exposure to the student for research methodology. This can include literature survey, review, data collection, and theoretical/ experimental work on small parts of research in area chosen by the faculty guiding the project work. If the project to be carried out at other institutions/ laboratories, the experts from these institutions are to be associated in choosing the research topic and its execution.

**15SAN101 SANSKRIT I** 1 0 2 2

**Objectives:** To familiarize students with Sanskrit language and literature; to enable them to read and understand Sanskrit verses and sentences; to help them acquire expertise for self-study of Sanskrit texts and communication in Sanskrit; to help the students imbibe values of life and Indian culture as propounded in scriptures.

**Unit 1**
Introduction to Sanskrit language, Devanagari script - Vowels and consonants, pronunciation, classification of consonants, conjunct consonants, words – nouns and verbs, cases – introduction, numbers, Pronouns, communicating time in Sanskrit. Practical classes in spoken Sanskrit

**Unit 2**
Verbs- Singular, Dual and plural – First person, Second person, Third person. Tenses – Past, Present and Future – Atmanepadi and Parasmaipadi - karthariprayoga

**Unit 3**
Words for communication, slokas, moral stories, subhashithas, riddles (from the books prescribed)

**Unit 4**

**Unit 5**
Translation of simple sentences from Sanskrit to English and vice versa.
**SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards**

**ESSENTIAL READING:**
1. Praveshahaa; Publisher: Samskrita bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560 085
2. Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad
3. PrakriyaBhashyamwritten and published by Fr. John Kunnappally
4. Sanskrit Primer by Edward Delavan Perry, published by Gin and Company Boston
5. Sabdamanjari, R.S. Vadyar and Sons, Kalpathi, Palakkad
6. Namalinganusasanam by Amarasisma published by Travancore Sanskrit series
7. Subhashita RatnaBhandakara by Kashinath Sharma, published by Nirnayasagarpress

**SANSKRIT II 1 0 2 2**

**Objectives:** To familiarize students with Sanskrit language and literature; to enable them to read and understand Sanskrit verses and sentences; to help them acquire expertise for self-study of Sanskrit texts and communication in Sanskrit; to help the students imbibe values of life and Indian culture as propounded in scriptures.

**Unit 1**
Seven cases, indeclinables, sentence making with indeclinables, Saptha karakas.

**Unit 2**
Ktavatu Pratyaya, Upasargas, Ktvanta, Tumunnanta, Lyabanta.
Three Lakaras – brief introduction, Lot lakara.

**Unit 3**
Words and sentences for advanced communication. Slokas, moral stories (Pancatantra) Subhashitas, riddles.

**Unit 4**
Introduction to classical literature, classification of Kavyas, classification of Dramas - The five Mahakavyas, selected slokas from devotional kavyas- Bhagavad Gita – chapter II verse 47, chapter IV verse 7, chapter VI verse 5, chapter VIII verse 6, chapter XVI verse 21, Kalidasa’s Sakuntala act IV verse 4, Isavasyopanishat 1st Mantra, Mahabharata chapter 149 verses 14- 120, Neetisara chapter - III

**Unit 5**
Translation of paragraphs from Sanskrit to English and vice versa.

**ESSENTIAL READING:**
1. Praveshahaa; Publisher: Samskritik bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560 085
2. Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad

**SSSK201 LIFE SKILLS I 1 0 2 2**

**Objectives:** To familiarize students with Sanskrit language and literature; to enable them to read and understand Sanskrit verses and sentences; to help them acquire expertise for self-study of Sanskrit texts and communication in Sanskrit; to help the students imbibe values of life and Indian culture as propounded in scriptures.

**Unit 1**
Seven cases, indeclinables, sentence making with indeclinables, Saptha karakas.

**Unit 2**
Ktavatu Pratyaya, Upasargas, Ktvanta, Tumunnanta, Lyabanta.
Three Lakaras – brief introduction, Lot lakara.

**Unit 3**
Words and sentences for advanced communication. Slokas, moral stories (Pancatantra) Subhashitas, riddles.

**Unit 4**
Introduction to classical literature, classification of Kavyas, classification of Dramas - The five Mahakavyas, selected slokas from devotional kavyas- Bhagavad Gita – chapter II verse 47, chapter IV verse 7, chapter VI verse 5, chapter VIII verse 6, chapter XVI verse 21, Kalidasa’s Sakuntala act IV verse 4, Isavasyopanishat 1st Mantra, Mahabharata chapter 149 verses 14- 120, Neetisara chapter - III

**Unit 5**
Translation of paragraphs from Sanskrit to English and vice versa.

**ESSENTIAL READING:**
1. Praveshahaa; Publisher: Samskritik bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560 085
2. Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad
SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

TEXTBOOKS:
4. The Hard Truth about Soft Skills, by Amazon Publication.

REFERENCES:
1. Quantitative Aptitude, by R S Aggarwal, S Chand Publ.
3. Data Interpretation, R S Aggarwal, S Chand Publ.
4. Nova GRE, KAPAL GRE, Barrons GRE books;
5. Quantitative Aptitude, The Institute of Chartered Accountants of India.
7. The BBC and British Council online resources
8. Owl Purdue University online teaching resources
9. www.thegrammarbook.com online teaching resources
10. www.englishpage.com online teaching resources and other useful websites.

15SSK211 LIFE SKILLS II 1022


Group Discussions: Advantages of Group Discussions, Structured GD – Roles, Negative roles to be avoided, Personality traits to do well in a GD, Initiation techniques, How to perform in a group discussion, Summarization techniques.

Listening Comprehension advanced: Exercise on improving listening skills, Grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc.

Reading Comprehension advanced: A course on how to approach middle level reading comprehension passages.

Problem solving – Money Related problems; Mixtures; Symbol Based problems; Clocks and Calendars; Simple, Linear, Quadratic and Polynomial Equations; Special Equations; Inequalities; Functions and Graphs; Sequence and Series; Set Theory; Permutations and Combinations; Probability; Statistics.

SYLLABI 5-yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Data Sufficiency: Concepts and Problem Solving.

Non-Verbal Reasoning and Simple Engineering Aptitude: Mirror Image; Water Image; Paper Folding; Paper Cutting; Grouping Of Figures; Figure Formation and Analysis; Completion of Incomplete Pattern; Figure Matrix; Miscellaneous.

Special Aptitude: Cloth, Leather, 2D and 3D Objects, Coin, Match Sticks, Stubs, Chalk, Chess Board, Land and geodesic problems etc., Related Problems.

TEXTBOOKS:
4. The Hard Truth about Soft Skills, by Amazon Publication.

REFERENCES:
1. Quantitative Aptitude, by R S Aggarwal, S Chand Publ.
5. The BBC and British Council online resources
6. Owl Purdue University online teaching resources
7. www.thegrammarbook.com online teaching resources
8. www.englishpage.com online teaching resources and other useful websites.

15SSK301 LIFE SKILLS III 1022


Facing an Interview: Foundation in core subject, Industry Orientation/ Knowledge about the company, Professional Personality, Communication Skills, activities before interview, upon entering interview room, during the interview and at the end. Mock interviews.

Advanced Grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc.
Syllogisms, Critical reasoning: A course on verbal reasoning. Listening Comprehension advanced: An exercise on improving listening skills.

Reading Comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Specific Training: Solving campus recruitment papers, National level and state level competitive examination papers; Speed mathematics; Tackling aptitude problems asked in interview; Techniques to remember (In Mathematics). Lateral Thinking problems. Quick checking of answers techniques; Techniques on elimination of options, Estimating and predicting correct answer; Time management in aptitude tests; Test taking strategies.

TEXTBOOKS:
4. The Hard Truth about Soft Skills, by Amazon Publication.

REFERENCES:
1. Speed Mathematics, Secrets of Lightning Mental Calculations, by Bill Handley, Master Mnd books;
2. The Trachtenberg Speed System of Basic Mathematics, Rupa & Co., Publishers;
5. Quick Arithmetics, by Ashish Agarwal, S Chand Publ.;
8. The BBC and British Council online resources
9. Owl Purdue University online teaching resources
10. www.thegrammarbook.com online teaching resources
11. www.englishpage.com online teaching resources and other useful websites.

15TAM101 TAMIL I 1 0 2 2

Objectives: To introduce the students to different literature - Sangam literature, Epics, Bhakti literature and modern literature; to improve their ability to communicate with creative concepts, and also to introduce them to the usefulness of basic grammatical components in Tamil.

Unit 1
Sangam literature: Kuguntaka (2. R. R. 40 pätalkal) – puranàtupu (74. 112. 184, 192 pätalkal) – tirukkurai (iraimâti, amaiâciu).

SYLLABI
5 yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 2
Epic literature: ciappadiiram maturai kântam (valakurakkâtkai 50-55).

Spiritual Literature: tiruppâvai (3,4) – têvâram (mâcîvinaityum)

Medieval Literature: bâratiyâr kannâm pâtu (eg vilâyiyâtu piilai) – bâratîcâçañ kutumpâvîlakkâ (tâyûn tâlântû).

Unit 3
Novel: Jeyâkântâ "kuru piitam"

Essay: Añâ ë tâñla latîlakâmë

Unit 4

SYLLABI
5 yr Integrated M Sc Maths/ Physics 2016 admissions onwards

Unit 2
Epic literature: ciappatikaram maturai kantam (valakurakkatkai 50-55).

Spiritual Literature: tiruppavai (3,4) – tevaram (macilvinaityum)

Medieval Literature: barratiyar kannag pattu (eg vilaiyiyitu pilla) – barratican kutumpavilakkku (tayin talsat).
SYLLABI

5-yr Integrated M Sc Maths/ Physics
2016 admissions onwards

Unit 1
The history of Tamil literature: Nāṭṭuṟu pongaḻaiṟgal, kataikkal, paḻamolḷakal - ciṟukataikal tōṟram valarciṟiyum, ciṟivalakkaiṇkaḷ: Kalirikuttup paraṇi (pōṟpāṭiyatu) - mukkōṭaḷ pāṭari 35.
Kāppiṟyaṇkaḷ: Cilappatikāram - maṉimēkkaḷai naṭṭalaiyar āṟyu māṟṟum anipparum - aṅtāṟṟiru kāppiṟyaṇkaḷ iḻṟṟṟuṟṟṟṟ geyṟkaiṟṟu.

Unit 2
tinai ilakkiyamum nīṟṟilakkiyamum - pōṟcoonikkōṅkkonikkōḷu nūḻkāḷ tōtṟṟṟṟo pōṟu ocṟkāḷ - tiṟkuṟṟṟṟu (āṟṟṟṟu, paṟṟṟṟu, kaiṟṟ, oḷḷuṟṟṟṟu, naṟṟṟṟu, vaṟṟyai, keḷḷi, ceṇṇaaṟṟṟu, peṇṇyāṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟற

Aṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟற

Unit 3
tamiḻ iakkanaṟṟu: vakkīyā vākairai - tāṟṟṟṟiru pируvai - nerkkuṟṟu ayarkurru.

Unit 4
tamiḻka eṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟற

Unit 5
tamiḻ moli āyvul kanini payṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟற

Textbooks:
http://www.tamilku.org/tryilinaapirthippinakuv.htm
http://www.tamiltamilch.in/2013/07/bhag3pozai_24.html
Mu. Varatarkaṉ “tamiḻ iakkkaṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟṟற

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