Syllabus for the First Degree Programme in B.Sc. Mathematics and Computer Applications (Double Main)
### SEMESTER-I

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**Division of marks (Lab examination)**

1. First program should be sufficiently simple (Logic – 10 marks, Successful compilation – 10 marks, Result – 5 marks) – 25 marks
2. Second program should be based on advanced concepts (Logic – 15 marks, Successful compilation – 10 marks, result – 5 marks) – 30 marks
3. Viva Voce – 15 marks
4. Lab Record – 10 marks

Total Marks – 80 marks

**MMC-1643 Project Evaluation criteria (Computer Applications)**

a. System analysis and design 20 marks
b. Output 20 marks
c. Candidate role and contribution in the project 20 marks
d. Demo & Presentation 20 marks
e. Viva 20 marks

Total 100 marks
SEMESTER-I
FOUNDATIONS OF MATHEMATICS

Code: MMC1131          Instructional hours per week: 3
No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to

CO-1. Understand the derivative of a function.
CO-2. Learn certain theorems on differentiation.
CO-3. Learn various applications also the physical interpretations of differentiation (derivative of a function).
CO-4. Understand the integration of a function and learn its physical interpretation through various examples.
CO-5. Learn various applications of integration.

Module I - Methods of Differential Calculus
(18 Hours)
Differentiating equations to relate rates, how derivatives can be used to approximate non-linear functions by linear functions, error in local linear approximation, differentials; Increasing and decreasing functions and their analysis, concavity of functions, points of inflections of a function and applications, finding relative maxima and minima of functions and graphing them, critical points, first and second derivative tests, multiplicity of roots and its geometrical interpretation, rational functions and their asymptotes, tangents and cusps on graphs; Motion along a line, velocity and speed, acceleration, Position - time curve, Rolle’s, Mean Value theorems and their consequences; Indeterminate forms and L’Hôpital’s rule;
The topics to be discussed in this module can be found in chapter 2, 3 and 6 of text [1] below.

Module II - Methods of Integral Calculus
(36 Hours)
Finding position, velocity, displacement, distance travelled of a particle by integration, analysing the distance-velocity curve, position and velocity when the acceleration is constant, analysing the free-fall motion of an object, finding average value of a function and its applications; Area, volume, length related concepts: Finding area between two curves, finding volumes of some three dimensional solids by various methods like slicing, disks and washers, cylindrical shells, finding length of a plane curve, surface of revolution and its area; Work done: Work done by a constant force and a variable force, relationship between work and energy; Relation between density and mass of objects, center of gravity, Pappus theorem and related problems Fluids, their density and pressure, fluid force on a vertical surface. Introduction to Hyperbolic functions and their applications in hanging cables; Improper integrals, their evaluation, applications such as finding arc length and area of surface;
The topics to be discussed in this module can be found in chapter 4, 5, 6 and 7 of text [1] below.

Texts

References
THEORY OF NUMBERS

Code: MMC 1132 Instructional hours per week: 3
No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to
CO-1. Become familiar with various kinds of numbers.
CO-2. Understand the role of numbers in other branches of Mathematics, in particular
Combinatorics, Set Theory and Algebra.
CO-3. Analyze different characters of number theoretic functions.
CO-4. Use number theoretical properties to solve real world problems.
CO-5. Applications of number theoretical concepts in various field and in particular
Cryptography.

Module I - Divisibility in integers (24 Hours)
The topic of elementary number theory is introduced for further developing the ideas in abstract
algebra. The following are the main topics in this module: The division algorithm, Pigeonhole
principle, divisibility relations, inclusion-exclusion principle, base-b representations of natural
numbers, prime and composite numbers, infinitude of primes, GCD, linear combination of
integers, pairwise relatively prime integers, the Euclidean algorithm for finding GCD, the
fundamental theorem of arithmetic, canonical decomposition of an integer into prime factors,
LCM; Linear Diophantine Equations and existence of solutions, Euler’s Method for solving LDE’s
The topics to be discussed in this module can be found in chapter 2 (except the topics the Egyptian
method of multiplication, the Russian Peasant Algorithm & Egyptian method of division in Section
2.2, Section 2.3 and 2.4, A Number - Theoretic Function onwards in Section 2.5, Section 2.6 and
2.7) and chapter 3 (except the topic A jigsaw puzzle onwards in Section 3.2, Factor Tree onwards

Module II - Congruence relations in integers (30 Hours)
Towards defining the congruence classes in Z, we begin with defining the congruence relation. Its
various properties should be discussed, and then the result that no prime of the form 4n + 3 is a
sum of two squares should be discussed. The other topics in this module are the following:
Defining congruence classes, complete set of residues, modulus exponentiation, finding reminder
of big numbers using modular arithmetic, cancellation laws in modular arithmetic, linear
congruences and existence of solutions, solving Mahavira’s puzzle, modular inverses, Pollard Rho
factoring method; Certain tests for divisibility - The numbers here to test are powers of 2, 3, 5, 7,
9, 10, 11, testing whether a given number is a square;

Linear system of congruence equations, Chinese Remainder Theorem and some applications;
Some classical results like Wilson's theorem, Fermat's little theorem, Pollard p – 1 factoring
method, Eulers’ theorem, The topics to be discussed in this module can be found in chapter 2 and
3 of text [1] below.

Texts
Text-1– Thomas Koshy. Elementary Number Theory with Applications, 2nd Edition,

References
ENVIRONMENTAL STUDIES
(Foundation Course-I)

Code: MMC 1121  Instructional hours per week: 2
No. of credits: 2

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

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<td>CO2</td>
<td>Understand different eco systems, environmental movements</td>
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<td>CO3</td>
<td>Understand types of natural resources</td>
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<td>CO4</td>
<td>Remember the causes and impacts of mining</td>
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<td>CO5</td>
<td>Understand bio diversity and conservation</td>
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<tr>
<td>CO6</td>
<td>Understand environment pollution</td>
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COURSE CONTENT


Module 2: Natural Resources: Renewable and Non-renewable Resources: Land Resources and land use change; Land degradation, soil erosion and desertification. Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water, Heating of earth and circulation of air; air mass formation and precipitation, Energy resources: Renewable and non-renewable energy sources, use of alternate, energy sources, growing energy needs

Module 3: Biodiversity and Conservation: Levels of biological diversity: genetic, species and ecosystem diversity; Biogeography zones of India; Biodiversity patterns and global biodiversity hotspots, India as a mega-biodiversity nation; Endangered and endemic species of India, Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value. Environmental Pollution: Environmental pollution: types, causes, effects and controls; Air, water, soil, chemical and noise pollution, Nuclear hazards and human health risks, Solid waste management: Control measures of urban and industrial waste, Pollution case studies.

REFERENCES


Assignment/Field work

- Visit to an area to document environmental assets; river/forest/flora/fauna, etc.
- Visit to a local polluted site – Urban/Rural/Industrial/Agricultural.
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge, etc.
INTRODUCTION TO COMPUTER SCIENCE

Code: MMC 1141  Instructional hours per week: 7 (5+2)
No. of credits: 4

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

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<td>CO3</td>
<td>Understand operating system and application software</td>
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<td>Understand online communication and web basics</td>
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<td>Remember network and internet basics</td>
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<td>CO6</td>
<td>Create documents in LaTex</td>
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COURSE CONTENT


The System Unit: Understanding CPUs, Understanding Memory, Understanding Motherboards, Understanding Power Supplies


Module 3: Networking and Internet Basics: Public Telephone and Data Networks, Ways of Classifying Networks, Network Hardware, Understanding and Connecting to the Internet

Online Communication: Internet Communication Types

Web Basics: How the Web Works, Accessing the Web with a Browse, Using Web Search Tools


TEXTBOOK
2. George Gratzer, Practical LaTex, Springer, 2014

REFERENCES
2. Dennis P Curtin, Information Technology: The Breaking wave, McGrawhill, 2014

LaTeX Lab (No End Semester Lab Examination) [36 Hours]

LATEX for preparing a project report in Mathematics

Graphical User Interface (GUI)/ Editor like Kile or TeX studio should be used for providing training to the students.

The main topics in this module are following:

Typesetting a simple article and compiling it:
How spaces are treated in the document;

Document layout: various options to be included in the document class command, page styles, splitting files into smaller files, breaking line and page, using boxes (like, mbox) to keep text unbroken across lines, dividing document in to parts like frontmatter, mainmatter, backmatter, chapters, sections, etc, cross referencing with and without page number, adding footnotes; Emphasizing words with \emph, \texttt, \textsl, \textit, \underline etc.

Basic environments like enumerate, itemize, description, flushleft, flusuright, center, quote, quotation Controlling enumeration via the enumerate package.

Tables: preparing a table and floating it, the longtable environment;

Typesetting mathematics : basic symbols, equations, operators, the equation environment and reference to it, the displaymath environment, exponents, arrows, basic functions, limits, fractions, spacing in the mathematics environments, matrices, aligning various objects, multi-equation environments, suppressing numbering for one or more equations, handling long equations, phantoms, using normal text in math mode, controlling font size, typesetting theorems, definitions, lemmas, etc, making text bold in math mode, inserting symbols and environments (array, pmatrixetc) using the support of GUIs;

Figures: Including JPG, PNG graphics with graphicx package, controlling width, height etc, floating figures, adding captions, the wrapfig package;

Adding references/bibliography and citing them, using the package hyperref to add and control hypertext links, creating presentations with pdf screen, creating new commands; Fonts : changing font size, various fonts, math fonts, Spacing : changing line spacing, controlling horizontal, vertical spacing, controlling the margins using the geometry package, full page package

Preparing a dummy project with title page, acknowledgement, certificates, table of contents (using \table of contents), list of tables, table of figures, chapters, sections, bibliography (using the bibliography environment).

This dummy project should contain at least one example from the each of the topic in the syllabus, and should be submitted for internal evaluation for 5 mark (assignment) before the end semester practical examination.
SEMESTER-II
DIFFERENTIAL EQUATIONS

CODE: MMC 1231 Instructional hours per week: 3
No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to-
CO-1. Learn various methods to solve first order linear differential equations.
CO-2. Learn the existence and uniqueness theorem of first order ordinary differential equation.
CO-3. Learn various methods to solve certain nonhomogeneous second order ordinary differential equations with constant coefficients.
CO-4. Learn the applications of ordinary differential equations.

In this course, we discuss how differential equations arise in various physical problems and consider some methods to solve first order differential equations and second order linear equations. For introducing the concepts, text[1] may be used, and for strengthening the theoretical aspects, reference [1] may be used.

Module I - First order ODE
(24 hours)
In this module we discuss first order equations and various methods to solve them. Sufficient number of exercises also should be done for understanding the concepts thoroughly. The main topics in this module are the following:
Modelling a problem, basic concept of a differential equation, its solution, initial value problems, geometric meaning (direction fields), separable ODE, reduction to separable form, exact ODEs and integrating factors, reducing to exact form, homogeneous and non-homogeneous linear ODEs, special equations like Bernoulli equation, orthogonal trajectories, understanding the existence and uniqueness of solutions theorem.
*The topics to be discussed in this module can be found in chapter 1 of text [1] below.*

Module II- Second order ODE
(30 hours)
As in the first module, we discuss second order equations and various methods to solve them. Sufficient number of exercises also should be done for understanding the concepts thoroughly. The main topics in this module are the following:
homogeneous linear ODE of second order, initial value problem, basis, and general solutions, finding a basis when one solution is known, homogeneous linear ODE with constant coefficients (various cases that arise depending on the characteristic equation), differential operators, Euler-Cauchy Equations, existence and uniqueness of solutions w.r.t wronskian, solving nonhomogeneous ODE via the method of undetermined coefficients, various applications of techniques, solution by variation of parameters.
*The topics to be discussed in this module can be found in chapter 2 of text [1] below.*

Texts
References
VECTOR CALCULUS

Code: MMC 1232  Instructional hours per week: 3
No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to
CO-1. Understand vectors and algebraic operations of vectors.
CO-2. Learn to compute the vector equation of a line.
CO-3. Understand the cylindrical and spherical coordinate systems.
CO-4. Learn calculus of vector valued functions.
CO-5. Understand the geometrical interpretation of Curvature and motion of a particle along a Curve through Calculus of Vectors.

Module I – Introduction to vector calculus  (24 Hours)
To begin with, the three dimensional rectangular co-ordinate system should be discussed and how distance is to be calculated between points in this system. Basic operations on vectors like their addition, cross and dot products should be introduced next. The concept of projections of vectors and the relation with dot product should be given emphasize. Equations of lines determined by a point and vector, vector equations in lines, equations of planes using vectors normal to be should be discussed. Quadric surfaces which are three dimensional analogues of conics should be discussed next. Various co-ordinate systems like cylindrical, spherical should be discussed next with the methods for conversion between various co-ordinate systems. The topics to be discussed in this module can be found in chapter 11 of text [1] below.

Module II - Vector valued functions  (30 Hours)
Towards going to the calculus of vector valued functions, we define such functions. The other topics in this module are the following: Parametric curves in the three dimensional space, limits, continuity and derivatives of vector valued functions, geometric interpretation of the derivative, basic rules of differentiation of such functions, derivatives of vector products, integrating vector functions, length of an arc of a parametric curve, change of parameter, arc length parametrizations,

various types of vectors that can be associated to a curve such as unit vectors, tangent vectors, binormal vectors, definition and various formulae for curvature, the geometrical interpretation of curvature, motion of a particle along a curve and geometrical interpretation of various vectors associated to it, various laws in astronomy like Kepler’s laws and problems. The topics to be discussed in this module can be found in chapter 12 of text [1] below.

Texts

References
INFORMATICS  
(Foundation Course-II)  

Code: MMC 1221  
Instructional hours per week: 3  
No. of credits: 3

CO 1: To introduce various online resources which will help students improve their teaching-learning experience.  

CO 2: The students will also be able to utilize these web resources to enhance their career and academics.  

CO 3: To provide awareness on cyber-crimes and cyber laws.

MODULE I: Introduction  
(10 Hours)  
Informatics: Meaning and Scope, Information Networks- INFLIBNET, NICNET. E-Books, Audio Books, Blogs, Podcasts, Massive Open Online Courses (MOOCs); Statistical Software for social science Research (Features of SPSS, E-Views, Gretl and R software)

MODULE: II: Data analysis  
(10 Hours)  

MODULE: III: The internet and E-Commerce.  
(16 Hours)  

MODULE: IV: Social informatics  
(18 Hours)  

Reference  
- PK Sinha, Computer Fundamentals, BPB Publications  
- Ramez Elmasri and Shamkant B Navathe, Fundamentals of data base Systems, Pearson  
- V Rajaraman, Fundamentals of Computers, PHI publications  
- Online resources (Tutorials on Excel)  
  - https://www.coursera.org/  
  - https://www.edx.org/  
  - https://www.swayam.gov.in  
  - http://www.learnerstv.com/  
  - http://www.inflibnet.ac.in  
  - http://www.bbc.co.uk/podcasts
PYTHON PROGRAMMING

Code: MMC 1241  Instructional hours per week: 4  No. of credits: 3

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

| CO1 | Remember data types and operators |
| CO2 | Understand decision making statements |
| CO3 | Apply exceptions |
| CO4 | Analyse different sorting methods |
| CO5 | Understand GUI programming concepts |
| CO6 | Create functions and modules |

COURSE CONTENT

Module 1: Introduction to Python - Features of Python - Identifiers - Reserved Keywords - Variables Comments in Python – Input, Output and Import Functions - Operators – Data Types and Operations – int, float, complex, Strings, List, Tuple, Set, Dictionary - Mutable and Immutable Objects – Data Type Conversion - Illustrative programs: selection sort, insertion sort, bubble sort

Module 2: Decision Making - conditional (if), alternative (if-else), if-elseif.-else, nested if - Loops for, range() while, break, continue, pass; Functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum of an array of numbers, linear search, binary search, bubble sort, insertion sort, selection sort

Module 3: Built-in Modules - Creating Modules - Import statement - Locating modules - Namespaces and Scope - The dir() function - The reload function - Packages in Python Files and exception: text files, reading and writing files Renaming and Deleting files Exception handling, Exception with arguments, Raising an Exception - User defined Exceptions - Assertions in


TEXT BOOK


REFERENCES

3. Timothy A. Budd, Exploring Python, Mc-Graw Hill Education (India) Private Ltd.
SAMPLE LAB EXERCISES
The laboratory work will consist of 10-15 Experiments

**Part A**: To write, test, and debug simple Python programs.
- To implement Python programs with conditionals and loops.
- Use functions for structuring Python programs.
- Represent compound data using Python lists, tuples, dictionaries.

**Part B**: Read and write data from/to files in Python.
- Programs to demonstrate creating and handling of modules and packages
- Programs involving a variety of Exception Handling situations
- GUI programming
SEMESTER- III
MULTI VARIABLE CALCULUS AND VECTOR CALCULUS

Code: MMC 1331 Instructional hours per week: 5
No. of credits: 4

Course Outcomes: At the end of the Course, the Student will be able to-
CO-1. Learn about functions of more than one variable.
CO-2. Understand the limit, continuity and differentiability of functions with more than
one variable.
CO-3. Understand various applications of multivariable calculus.
CO-4. Learn the integration of vector valued function.
CO-5. Learn various applications of integration of vector valued functions.

Module I- Multivariable Calculus (45 Hours)
After introducing the concept of functions of more than one variable, the sketching of them in
three dimensional cases with the help of level curves should be discussed. Contours and level
surface plotting also should be discussed. The other topics in this module are the following: Limits
and continuity of Multivariable functions, various results related to finding the limits and
establishing continuity, continuity at boundary points, partial derivatives of functions, partial
derivative as a function, its geometrical interpretation, implicit partial differentiation, changing
the order of partial differentiation and the equality conditions; Differentiability of a multivariate
function, differentiability of such a function implies its continuity, local linear approximations,
chain rules - various versions, directional derivative and differentiability, gradient and its
properties, applications of gradients; Tangent planes and normal vectors to level surfaces, finding
tangent lines to intersections of surfaces, extrema of multivariate functions, techniques to find
them, critical and saddle points, Lagrange multipliers to solve extremum problems with constrains.
The topics to be discussed in this module can be found in chapter 13 of text [1]below.

Module II - Vector Calculus (45 Hours)
After the differentiation of vector valued functions in the last semester, here we introduce the
concept of integrating vector valued functions. Some important theorems are also to be discussed
here. The main topics are the following: Vector fields and their graphical representation, various
type of vector fields (inverse- square, gradient, conservative), potential functions, divergence, curl,
the 5 operator, Laplacian; Integrating a function along a curve (line integrals), integrating a vector
field along a curve, defining work done as a line integral, line integrals along piece wise-smooth
curves, integration of vector fields and independence of path, fundamental theorem of line
integrals, line integrals along closed paths, test for conservative vector fields, Green’s theorem and
applications; Defining and evaluating surface integrals, their applications, orientation of surfaces,
evaluating flux integrals, The divergence theorem, Gauss’ Law, Stoke's theorem, applications of
these theorems. The topics to be discussed in this module can be found in chapter 15 of text [1]
below.

Texts

References
Company
India Private Limited.
ABSTRACT ALGEBRA – GROUP THEORY

Code: MMC 1332  Instructional hours per week: 5  No. of credits: 4

Course Outcomes: At the end of the Course, the Student will be able to-

CO-1. Understand the definition of group and its various properties through examples.
CO-2. Understand subgroups, cyclic groups and various properties of the same.
CO-3. One will be able to understand permutation groups.
CO-4. Learn the well-known Cayley’s and Lagrange’s theorem.
CO-5. Learn certain applications of group theory.

The aim of this course is to provide a very strong foundation in the theory of groups. The concepts in the course are to be supported by examples mainly from the references.

Module I  (30 Hours)
The concept of group is to be introduced before rigorously defining it. The symmetries of a square can be a starting point for this. After that, definition of group should be stated and should be clarified with the help of examples. After discussing various properties of groups, finite groups and their examples should be discussed. The concept of subgroups with various characterizations also should be discussed. After introducing the definition of cyclic groups, various examples, and important features of cyclic groups and results on order of elements in such groups should be discussed.

The topics to be discussed in this module can be found in chapter 1, 2 3 and 4 of text [1] below.

Module II  (24 Hours)
This module starts with defining and analyzing various properties permutation groups which forms one of the most important class of examples for non-abelian, finite groups. After defining operations on permutations, their properties are to be discussed. To motivate the students, the example of check-digit scheme should be discussed (This section on check-digit scheme is not meant for the examinations). Then we proceed to define the notion of equivalence of groups viz. isomorphisms. Several examples are to be discussed for explaining this notion. The properties of isomorphisms are also to be discussed together with special classes of isomorphisms like automorphisms and inner automorphisms before finishing the module with the classic result of Cayley on finite groups.

The topics to be discussed in this module can be found in chapter 5 and 6 of text [1] below.

Module III  (18 Hours)
In this module we prove one of the most important results in group theory which is the Langrange’s theorem on counting cosets of a finite group. The concept of cosets of a group should be defined giving many examples before proving the Lagrange’s theorem. As some of the applications of this theorem, the connection between permutation groups and rotations of cube and soccer ball should be discussed. The section on Rubik’s cube and section on internal direct products need not be discussed.

The topics to be discussed in this module can be found in chapter 7 and 9 of text [1] below.

Module IV  (18 hours)
Here the concept of group homomorphisms should be defined with sufficient number of examples. After proving the first isomorphism theorem, the fundamental theorem of isomorphism should be introduced without proof. Classifying groups based on the fundamental theorem should be discussed in detail.

The topics to be discussed in this module can be found in chapter 10 and 11 of text [1] below.

Texts

References
Ref. 2 – I. N. Herstein. Topics in Algebra, Vikas Publications
COMPUTER GRAPHICS

CODE: MMC 1341
Instructional hours per week: 5 (3+2)
No. of credits: 5

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

| CO1  | Remember graphics primitives |
| CO2  | Understand different transformations |
| CO3  | Apply clipping algorithm to different models |
| CO4  | Analyse different line drawing algorithms |
| CO5  | Understand color illumination models |
| CO6  | Understand types of projections |

COURSE CONTENT

Module 1: Introduction: graphic data representation, concept of pixels, resolution, aspect ratio, Raster scan display, Random Scan display, video adapter, frame buffer, display technology-CRT, LCD, LED, smart devices (feature wise comparison only), Output Primitives: Straight Line, DDA algorithm, Bresenham's Line Algorithm, Circle- Mid Point Circle Algorithm, polygon filling algorithms- boundary fill, scan-line algorithm, Aliasing and Anti-aliasing.

Module 2: Two dimensional Transformations: Translation, scaling, fixed point scaling, rotation, reflection, transformation with respect to arbitrary points. Application of homogeneous coordinates for uniform matrix operations, composite transformations, Windowing and clipping: Window to viewport transformation, Clipping- Point clipping, Line Clipping, Cohen-Sutherland Line Clipping algorithms, Polygon Clipping-Sutherland-hodgeman algorithm.


Module 4: Colour Illumination methods: colour models-RGB, HSI, CMYK, Illumination model and light sources, Specular reflection, Intensity attenuation, shadow, Polygon Shading methods, animation, morphing, tweening, warping, zooming, panning, rubber band lines (concepts only)

TEXT BOOK

REFERENCES

SageMath_Lab (No End Semester Examination)[36 Hours]

Starting SageMath using a browser, how to use the sage cell server https://sagecell.sagemath.org/, how to use SageMathCloud, creating and saving a sage worksheet, saving the worksheet to an .sws file, moving it and re-opening it in another computer system; Using sagemath as a calculator, basic functions (square root, logarithm, numeric value, exponential, trigonometric, conversion between degrees and radians, etc.);

Plotting: simple plots of known functions, controlling range of plots, controlling axes, labels, gridlines, drawing multiple plots on a single picture, adding plots, polar plotting, plotting implicit functions, contour plots, level sets, parametric 2D plotting, vector fields plotting, gradients;
Matrix Algebra: Adding, multiplying two matrices, row reduced echelon forms to solve linear system of equations, finding inverses of square matrices, determinants, exponentiation of matrices, computing the kernel of a matrix; Defining own functions and using it, composing functions, multivariate functions;

Polynomials: Defining polynomials, operations on them like multiplication and division, expanding a product, factorizing a polynomial, finding gcd;

Solving single variable equations, declaring multiple variables, solving multi variable equations, solving system of non-linear equations

Internal Evaluation: Another practical record should be submitted the content of which should be problems and their outputs evaluated using SageMath. This record should be awarded a maximum of 5 marks (Assignment mark) which is earmarked for the internal evaluation examination.
OPERATING SYSTEM

CODE: MMC 1342            Instructional hours per week: 5
No. of credits: 4

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

<table>
<thead>
<tr>
<th>No.</th>
<th>Course Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Remember functions, types and characteristics of operating systems</td>
</tr>
<tr>
<td>CO2</td>
<td>Understand process management</td>
</tr>
<tr>
<td>CO3</td>
<td>Apply CPU scheduling algorithms for different number of jobs</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyse different deadlock situations, disk scheduling algorithms</td>
</tr>
<tr>
<td>CO5</td>
<td>Evaluate synchronization problems</td>
</tr>
<tr>
<td>CO6</td>
<td>Understand memory allocation methods</td>
</tr>
</tbody>
</table>

COURSE CONTENT

Module 1: Introduction to operating system: Operating system as the main component of system software; OS as a resource manager, Structure of OS- shell, utilities, resource management routines, kernel, evolution of OS, multiprogramming, time sharing, real-time systems, parallel systems, distributed systems, OS functions, Characteristics of modern OS; Process Management: Process description and control: process control block, Process states: operations on processes; concurrent process; threads; processes and threads; symmetric multiprocessing; micro Kernels. CPU Scheduling: Schedulers, Scheduling methodology, CPU Scheduling algorithms, performance comparison.


Module 3: Memory Management & Protection: Concept of memory, address binding, Logical address, physical address, swapping, contiguous allocation- fixed partition, variable partition, fragmentation. Non-contiguous allocation- paging, segmentation. Virtual memory demand paging, page fault, replacement algorithms, thrashing. Protection and security – mechanisms and policies, threats, accidental data loss, protection mechanisms, user authentication, attacks from inside, virus, antivirus.


TEXT BOOK
1. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, Operating System Principles

REFERENCES
1. Achyut S Godbole, Operating systems, McGraw-Hill, Third Edition
SEMESTER-IV
ABSTRACT ALGEBRA – RING THEORY

CODE: MMC143I
Instructional hours per week: 5
No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to-
CO-1. Understand the definition, various properties of rings through examples.
CO-2. Understand the definition and various properties of prime ideal and maximal ideal.
CO-3. Understand the definition of ring homomorphism and various properties of the same.
CO-4. Learn polynomial rings, reducibility, irreducibility and the unique factorization of some polynomial rings.
CO-5. Learn divisibility properties of various integral domains.
CO-6. Learn unique factorization domains and Euclidean domains through examples.

After discussing the theory of groups thoroughly in the previous semester, we move towards the next higher algebraic structure rings. As in the last semester, all the new concepts appearing in the course is to be supported by numerous examples mainly from the references provided.

Module I
The concept of rings, subrings with many examples should be discussed here. Next comes the definition and properties of integral domains, fields, and the characteristic of rings. Ideals, how factor rings are defined using ideals, should be explained next. The definition of prime and maximal ideals with examples should be discussed after that.

The topics to be discussed in this module can be found in chapter 12, 13 and 14 of text [1] below.

Module II
After introducing the definition of ring homomorphisms, their properties should be discussed. The field of quotients of an integral domain should be discussed next. The next topic is the definition and various properties of polynomial rings over a commutative ring. Various results on operations on polynomials such as division algorithm, factor theorem, remainder theorem etc should be discussed next. The definition and examples of PID’s should be discussed next, before moving to the factorization of polynomials. Tests of irreducibility and reducibility and the unique factorization of polynomials over special rings should be discussed.

The topics to be discussed in this module can be found in chapter 15, 16 and 17 of text [1] below.

Module III
In the last module, we introduce more rigorous topics like various type of integral domains. The divisibility properties of integral domains and definition of primes in a general ring should be introduced. Unique factorization domains and the Euclidean domains should be discussed next with examples. Results on the special integral domains are also to be discussed.

The topics to be discussed in this module can be found in chapter 18 of text [1] below.

Texts

References
Ref. 1 – D S Dummit, R M Foote; Abstract Algebra, 3rd Edition, Wiley
Ref. 2 – I N Herstein, Topics in Algebra, Vikas Publications
Course Outcomes: At the end of the Course, the Student will be able to-
   CO-1. Learn the Gauss Elimination method also one will be able to find inverse of matrices by the elimination method.
   CO-2. One will be able to solve a non-homogeneous linear system of equations.
   CO-3. Understand the basis and dimension of a Vector space.
   CO-4. Learn linear transformation on a vector space through certain examples.
   CO-5. Understand the Eigen values of a matrix.
   CO-6. Learn the diagonalization of a matrix.

The main focus of this course is to introduce linear algebra and methods in it for solving practical problems.

Module-I (25 Hours)
This module deals with a study on linear equations and their geometry. After introducing the geometrical interpretation of linear equations, following topics should be discussed: various operations on column vectors, technique of Gaussian elimination, operations involving elementary matrices, interchanging of rows using elementary matrices, triangular factorization of matrices and finding inverse of matrices by the elimination method.

The topics to be discussed in this module can be found in chapter 1 of text [1] below. The section 1.7 may be omitted.

Module-II (30 hours)
Towards the study of vector spaces, specifically $\mathbb{R}^n$, we define them with many examples. Subspaces are to be defined next. After discussing the idea of nullspace of a matrix. The solving linear equations (which was one to some extent in the first module) and finding solutions to non-homogeneous systems from the corresponding homogeneous systems. After this, linear independence and dependence of vectors, their spanning, basis for a space, its dimension concepts are to be introduced. The column, row, null, left null spaces of a matrix is to be discussed next. When inverses of a matrix exists related to its column/row rank should be discussed. Towards the end of this module, linear transformations (through matrices) and their properties are to be discussed. Types of transformations like rotations, projections, reflections are to be considered next.

The topics to be discussed in this module can be found in chapter 2 of text [1] below. The section 2.7 on graphs and networks may be omitted.

Module-III (35 hours)
This module is intended for making the idea and concepts of determinants stronger. Its properties like what happens when rows are interchanged, linearity of expansion long the first row etc. are to be discussed. Breaking a matrix into triangular, diagonal forms and finding the determinants, expansion in cofactors, their applications like solving system of equations, finding volume etc. are to be discussed next.

We conclude our analysis of matrices. The problem of finding eigen values a matrix is to be introduced first. Next goal is to diagonalize a matrix. This concept should be discussed first, and move to the discussion on the use of eigenvectors in diagonalization.
The topics to be discussed in this module can be found in chapter 4 and 5 of text [1] below.

**Texts**


**References**


Ref. 4 – David C Lay: *Linear Algebra*, Pearson

Ref. 5 – K Hoffman and R Kunze: *Linear Algebra*, PHI
ALGORITHMS AND DATA STRUCTURES

CODE: MMC 1441  
Instructional hours per week: 4  
No. of credits: 4

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

<table>
<thead>
<tr>
<th>No.</th>
<th>OUTCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Remember properties of a good algorithm</td>
</tr>
<tr>
<td>CO2</td>
<td>Understand operations of stack and queues</td>
</tr>
<tr>
<td>CO3</td>
<td>Apply pointer concept in linked list</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyse different sorting algorithms</td>
</tr>
<tr>
<td>CO5</td>
<td>Evaluate different expressions</td>
</tr>
<tr>
<td>CO6</td>
<td>Create binary from a given infix notation</td>
</tr>
</tbody>
</table>

COURSE CONTENT


Module 2: Sorting: Bubble sort, Selection sort, Quick Sort, Insertion Sort, Merge Sort; Arrays: operations on arrays insertion, deletion and traversing; Linked Lists: Concept of static versus dynamic data structures, implementation of linked lists using pointers, operations on linked lists: insertion, deletion and traversing. Doubly linked lists and circular linked lists, applications of linked lists.

Module 3: Stacks and Queues: FIFO and LIFO data structures – stacks using (i) pointers and (ii) arrays. Queues using (i) pointers and (ii) arrays, Operations on stack and queues; applications, polish notation.

Module 4: Trees: Concept of linear versus non-linear data structures, various types of trees – binary, binary search trees. Creating a binary search tree, traversing a binary tree (in-order, pre-order and post-order), operations on a tree –insertion, deletion and processing, expression trees, implementation using pointers, applications; Graphs, graph traversal- depth-first and breadth-first traversal of graphs, applications.

TEXT BOOK


REFERENCES

WEB PROGRAMMING

CODE: MMC 142

Instructional hours per week: 2+2=4
No. of credits: 4

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

<table>
<thead>
<tr>
<th>No.</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Remember tags in HTML</td>
</tr>
<tr>
<td>CO2</td>
<td>Understand linking of web pages and inclusion of frames</td>
</tr>
<tr>
<td>CO3</td>
<td>Apply style sheets in web pages</td>
</tr>
<tr>
<td>CO4</td>
<td>Understand stylesheet basics</td>
</tr>
<tr>
<td>CO5</td>
<td>Understand DHTML</td>
</tr>
<tr>
<td>CO6</td>
<td>Create a web site using HTML and javascript</td>
</tr>
</tbody>
</table>

COURSE CONTENT

Module 1: HTML - General Introduction to Internet and WWW; HTML: Structured language, Document types, Rules of html, Html tags, Head tags, Body tags, Headings, Divisions and Centering, Quotations, Preformatted text, Lists, Horizontal Rules, Block level elements, Text level elements, Character entities, Comments, Fonts, Tables: Table tags, Colors, Color names, Color values, Marquee.


Module 3: JavaScript - Introduction to JavaScript, Variables and data types, Declaring Variables, Operators, Control Structures, Conditional Statements, Loop Statements, Functions, Objects, Dialog Boxes, Alert Boxes, Confirm Boxes, Prompt Boxes, JavaScript with HTML, Events, Arrays, Predefined objects, DHTML, Page Redirect, Void Keyword, Page Printing, String Methods, Error Handling, Validations, Publishing your Site, Cookies

Module 4: CSS & XML: Style sheet Basics, Adding Style to a Document, CSS (Cascading Style Sheet) and HTML Elements, Selectors, Document Structure, and Inheritance.

TEXT BOOK

REFERENCES
3. H M Deitel, P J Deitel & A B Goldberg, Internet and WWW programming:, 3/e, Pearson
DATA STRUCTURES LAB

CODE: MMC 144L1

 Instructional hours per week: 2
 No. of credits: 2

SAMPLE LAB EXERCISES

Part A
- Linked list: traversal, node deletion, node insertion in singly, doubly and circular lists
- Implementation of different searching techniques
- Implementation of different sorting techniques

Part B
- Stacks: matrix representation and linked list representation: Push, Pop
- Queues: matrix representation and linked list representation: Add, delete
- Circular queue implementation
- Evaluation of expression using stacks
- Tree traversal
- Evaluation of expression using binary trees.
- Infix to postfix and prefix conversion
- Creating and processing binary search tree
Course Outcomes: At the end of the Course, the Student will be able to-

CO-1. Understand sequence and series of real numbers.
CO-2. Learn the existence of an irrational number in R, completeness property of R, density of rational numbers on R.
CO-3. Learn uncountability and various cardinality results on R.
CO-4. Learn the convergence of sequences and series of real numbers.
CO-5. Learn certain important theorems namely the Bolzano - Weierstrass theorem, the Cauchy criterion for convergence of a sequence and the Monotone convergence theorem.

In this course, we discuss the notion of real numbers, the ideas of sequence of real numbers and the concept of infinite summation in a formal manner. Many of the topics discussed in the first two modules of this course were introduced somewhat informally in earlier courses, but in this course, the emphasis is on mathematical rigor. A minimal introduction to the metric space structure of R is also included so as to serve as a stepping stone into the idea of abstract topological spaces. The course is mainly based on Chapters 1–3 of text [1].

All the chapters mentioned above contains a section titled Discussions in the beginning of the chapter. This section is intended only for motivating the students, and so should not be made as a part of the examination process.

Module-I
This module introduces the basic concepts about the real number system with some introduction to sets, functions, and proof techniques. The following are the main topics to be discussed: existence of an irrational number, the axiom of completeness, upper lower bounds of sets in R, consequences of completeness like Archimedian property of real numbers, Density of Q in R, existence of square roots, countability of Q and uncountability of R, various cardinality results, Cantor’s original proof for uncountability of R, and Cantor’s theorem on power sets.

The topics to be discussed in this module can be found in chapter 1 of text [1] below. The first section 1.1 may be briefly discussed and is not meant for examination purposes.

Module-II
Students must have already encountered the idea of infinite series through the example of geometric progression. After discussing the rearrangement concept of infinite series, the following topics are to be introduced rigorously: Limit of a sequence, diverging sequences, examples, algebraic operations on limits, and order properties of sequences and limits, the Monotone Convergence Theorem, Cauchy’s condensation test for convergence of a series, various other tests for the convergence series, the Bolzano-Weierstrass theorem, the Cauchy criterion for convergence of a sequence, rearrangement of absolutely convergent series.

The topics to be discussed in this module can be found in chapter 2 of text [1] below. The first section 2.1 may be briefly discussed and is not meant for examination purposes.
Module-III

This module is intended to be a beginner for learning abstract metric spaces. To motivate the students, the Cantor set should be constructed and shown in the beginning. Then move to the topics open and closed sets in $\mathbb{R}$, and what about their completeness, Compactness of sets (defined using sequential convergence), open covers and compactness.

The topics to be discussed in this module can be found in chapter 3 of text [1] below. The first section 3.1 may be briefly discussed and is not meant for examination purposes. The sections 3.4 and 3.5 need not be discussed.

Texts

References
Ref. 3 – Terrence Tao. *Analysis I*, Hindustan Book Agency
COMPLEX ANALYSIS –I

CODE: MMC 1532 Instructional hours per week: 5
No. of credits: 4

Course Outcomes: At the end of the Course, the Student will be able to-
CO-1. Understand the algebra of Complex numbers.
CO-2. Learn how to find the polar form of a complex number.
CO-3. Understand the limit, continuity and analyticity of Complex function.
CO-4. Learn Cauchy Riemann equations and Harmonic functions.
CO-5. Learn about certain elementary complex functions.

Here we go through the basic complex function theory.

Module-I (35 Hours)
Complex numbers: The algebra of Complex Numbers, Point Representation of Complex Numbers, Vectors and Polar forms, The Complex Exponential, Powers and Roots, Planar Sets
Analytic Functions: Functions of a complex variable, Limits and Continuity, Analyticity, The Cauchy Riemann Equations, Harmonic Functions
The topics to be discussed in this module can be found in chapter 1, sections 1.1, 1.2, 1.3, 1.4, 1.5, 1.6 and chapter 2, sections 2.1, 2.2, 2.3, 2.4, 2.5 of text [1] below.

Module-II (25 hours)
Elementary Functions: Polynomials and rational Functions (Proof of the theorem on partial fraction decomposition need not be discussed), The Exponential, Trigonometric and Hyperbolic Functions, The Logarithmic Function, Complex Powers and Inverse Trigonometric Functions.
The topics to be discussed in this module can be found in chapter 3, sections 3.1, 3.2, 3.3, of text [1] below.

Module-III (30 hours)
Complex Integration: Contours, Contour Integrals, Independence of Path, Cauchy’s Integral Theorem (Section 4.4a on deformation of Contours Approach is to be discussed, but section 4.4 b on Vector Analysis Approach need not be discussed), Cauchy’s Integral Formula and Its Consequences, Bounds of Analytic Functions
The topics to be discussed in this module can be found in chapter 4, sections 4.1, 4.2, 4.3, 4.4a, 4.5 and 4.6 of text [1] below.

Texts

References
Ref. 1– John H Mathews, Russel W Howell. Complex Analysis for Mathematics and Engineering, Jones and Bartlett Publishers

32
To complete the undergraduate programme, the students should undertake a project and prepare and submit a project report on a topic of their choice in the subject mathematics or allied subjects. The work on the project should start in the beginning of the 5th semester itself, and should end towards the middle of the 6th semester. This course (without any examination in the 5th semester, with a project report submission and project viva in the 6th semester) is introduced for making the students understand various concepts behind undertaking such a project and preparing the final report. Towards the end of this course the students should be able to choose and prepare topics in their own and they should understand the layout of a project report.

To quickly get into the business, the first chapter of text [1] may be completely discussed. Apart from that, for detailed information, the other chapters in this book may be used in association with the other references given below. The main topics to discuss in this course are the following:

**Quick overview:** The structure of Dissertation, creating a plan for the Dissertation, planning the results section, planning the introduction, planning and writing the abstract, composing the title, figures, tables, and appendices, references, making good presentations, handling resources like notebooks, library, computers etc., preparing an interim report.

**Topics in detail:** Planning and Writing the Introduction, Planning and Writing the Results, Figures and Tables, Planning and Writing the Discussion, Planning and Writing the References, Deciding On a Title and Planning and Writing the Other Bits, Proofreading, Printing, Binding and Submission, oral examinations, preparing for viva, Taking the Dissertation to the Viva Layout: Fonts and Line Spacing, Margins, Headers, and Footers, Alignment of Text, Titles and Headings, Separating Sections and Chapters

**Texts**
Text 1 – Daniel Holtom, Elizabeth Fisher. *Enjoy Writing Your Science Thesis or Dissertation–A step by step guide to planning and writing dissertations and theses for undergraduate and graduate science students*, Imperial College Press

**References**
SOFTWARE ENGINEERING

CODE: MMC 1541

Instructional hours per week: 4
No. of credits: 4

COURSE OUTCOMES: at the end of the Course, the Student will be able to:

| CO1 | Remember characteristics of software and process |
| CO2 | Understand coding and testing methods |
| CO3 | Apply object oriented design concepts |
| CO4 | Analyse various software development process models |
| CO5 | Evaluate cost and efforts |
| CO6 | Create DFD of a software system |

COURSE CONTENT

Module 1: Introduction: Characteristics of software, product and process, need for software process, characteristics of a software process, software development process models, software development life cycle model: waterfall model, prototyping, iterative development, spiral model, time-boxing model; comparison of different life cycle models, software project management, project estimation techniques, software requirements analysis and definition: software requirements, overview of SA/SD methodology, requirements specification: need for SRS, characteristics of an SRS, components of an SRS, specification languages, structure of a requirements document. Functional specification with use cases, developing use cases, structured analysis, metrics, quality metrics, planning a project, effort estimation, COCOMO model, quality plan, risk management-assessment, control.

Module 2: Function oriented design: Problem partitioning, abstraction, modularity, Top-down and Bottom-up Strategies, coupling, cohesion, design notations-structure charts, structured design, data flow diagrams, developing the DFD model of a system, entity relationship diagram, developing ERD of a system, decision trees, decision tables, structured English, first-level factoring, factoring input, output and transform branches, transaction analysis, verification.

Module 3: Object-oriented design: Object-oriented design concepts, comparison between algorithmic decomposition and object oriented decomposition unified modelling language, object oriented design using UML, class diagram, sequence diagram, collaboration diagram; detailed design, PDL, algorithm design, state modelling of classes, design walkthroughs, critical design review, consistency checkers, other UML diagrams.

Module 4: Coding and testing: common coding errors, structured programming, coding standards, incremental coding process, test driven development, source code control and build, refactoring, verification- code inspections, static analysis, unit testing, combining different techniques. Testing- error, fault and failure, test oracles, test cases, Black Box Testing, equivalence class partitioning, boundary value analysis, cause effect graphing, white Box Testing- control flow based and data-flow based testing, test plan, test case specifications, defect logging and tracking, comparison of different techniques.

TEXT BOOK

REFERENCES
DATABASE MANAGEMENT SYSTEMS

Code: MMC 1542  Instructional hours per week: 4+2=6
No. of credits: 5

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

| CO1 | Remember Evolution of Database system |
| CO2 | Understand set operations on relations |
| CO3 | Apply different normal forms in relational database |
| CO4 | Understand design and maintenance issues |
| CO5 | Understand Entity Relationship model |
| CO6 | Create different queries in SQL |

COURSE CONTENT

Module 1: Introduction: evolution of database systems, overview of database management systems, Relational data model, mathematical definition, candidate, primary and foreign keys, set operations on relations, insertion, deletion and update operations, attribute domains.

Module 2: Relational algebra and relational calculus, Introduction to SQL, Table creation, selection, projection and join using SQL.

Module 3: Functional Dependencies – Inference axioms, normalization, 1NF, 2NF, 3NF and Boyce-Codd Normal forms, Lossless and lossy decompositions.

Module 4: The E-R Model, Entities and attributes, 1-1 and many-1, many-many relationships. Security – Physical and Logical, Design and maintenance issues, integrity.

TEXT BOOK

REFERENCES
1. Atul Kahate, Introduction to Data Base Management Systems, Pearson Education
2. www.pearson.co.in/AtulKahate,
3. www.edugrid.ac.in/webfolder/courses/dbms/dbms_indEX.htm

DBMS LAB (No End Semester Lab Examination) - SAMPLE LAB EXERCISES

Part A
- SQL statement for creating, listing, dropping, checking, updating tables
- Record manipulation using-insert, delete, update
- Experiments that clarify the importance of keys (Except foreign key)
- Queries with an Expression and a column alias
- A simple query that aggregates (groups) over a whole table
- A query with a literal string in the SELECT list
- Queries with sub string comparison and ordering
- Query using the "IS NULL" syntax to list (compare ‘=NULL’ instead of IS NULL”)
- Finding values within a certain range
- Using the --"BETWEEN" keyword
- SQL functions (String, Numeric, Date functions)
- Aggregate Functions

Part B
- A Join between two tables (Natural Join, Theta Join etc.)
- Foreign Key
- Nested queries
- The EXISTS and UNIQUE function in SQL
- Renaming attributes and joined tables
- Statements related with VIEWs
DIGITAL MARKETING (OPEN COURSE)

CODE: MMC 1551.1 Instructional hours per week: 3
No. of credits: 2

COURSE OUTCOME

| CO1 | Remember core concepts in digital marketing |
| CO2 | Understand E Banking approaches devices, benefits and drawbacks |
| CO3 | Understand Encryption and decryption |
| CO4 | Understand social media marketing |
| CO5 | Understand search engine advertising |
| CO6 | Understand Search engine optimization |

COURSE CONTENT


Module II: E-banking: approaches, devices, services, benefits, drawbacks, Electronic payment systems-credit cards, debit cards, smart cards, credit accounts, cyber security, encryption, secret key cryptography, public key cryptography, digital signatures, firewalls

Module III: Digital Marketing: Search Engine Optimization (SEO), Social Media, Content Marketing; Email Marketing, Mobile Marketing. Challenges for Digital Marketing: Increased Security Risk, Cluttered Market, Less Focus on Keywords, More Ad Blockers, Increased Ad Costs.

Module IV: Digital Marketing: Pay per Click-Search Engine Advertising, Advantages, Factors, Conversion Rate Optimization (CRO); Digital Marketing- Web Analytic. Social Media Marketing: Face book, Pinterest, Twitter, LinkedIn, YouTube, Google Adwords, Google Analytics; Issues and Future enhancement of Digital Marketing.

TEXT BOOK

- Ian Dodson- The art of Digital Marketing, Wiley

REFERENCE

- Puneet Singh Bhatia- Fundamentals of Digital Marketing, Pearson Education
INTERNET AND WWW (OPEN COURSE)

CODE: MMC 1551.2 Instructional hours per week: 3
No. of credits: 2

COURSE OUTCOME

<table>
<thead>
<tr>
<th>CO1</th>
<th>Remember network topologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Understand modes of connecting internet</td>
</tr>
<tr>
<td>CO3</td>
<td>Understand WWW fundamentals</td>
</tr>
<tr>
<td>CO4</td>
<td>Understand browsers and search engines</td>
</tr>
<tr>
<td>CO5</td>
<td>Understand TCP/IP model</td>
</tr>
<tr>
<td>CO6</td>
<td>Remember benefits of web server</td>
</tr>
</tbody>
</table>

COURSE OUTCOME


Module III: Uniform Resource Locator (URL) Introduction to TCP/IP-TCP/IP Model, Email-Working with Email-Sending Mail-Reading Mail-Replying to Mail-Deleting Mail-Advantages and Disadvantages of Email, Basics of Chat Rooms, SMTP.


TEXT BOOK
• Dr.Surender Jangra, “Basics of Internet and Web”, Vayu Education of India. New Delhi 110002

REFERENCE
CYBER SECURITY (OPEN COURSE)

CODE: MMC 1551.3  Instructional hours per week: 3  
No. of credits: 2

COURSE OUTCOMES

<table>
<thead>
<tr>
<th>No.</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Remember fundamental concepts of information systems</td>
</tr>
<tr>
<td>CO2</td>
<td>Understand Data security considerations</td>
</tr>
<tr>
<td>CO3</td>
<td>Understand social threats</td>
</tr>
<tr>
<td>CO4</td>
<td>Understand security policies</td>
</tr>
<tr>
<td>CO5</td>
<td>Understand information security standards</td>
</tr>
<tr>
<td>CO6</td>
<td>Remember cyber laws in India</td>
</tr>
</tbody>
</table>

COURSE CONTENT

Module I: Introduction to Information systems: Modeling business process, components, categories, Individuals in information system, Developing information systems; Information Systems: threats, Information assurance, cyber security and security risk analysis; Application security: Data Security considerations, security technology, intrusion detection access control

Module II: Security threats: Introduction to security threats, Network and services attack, security threats to e-commerce.


TEXT BOOK
- Fundamentals of Cyber security, Mayank Bhushan, BPB publication, First Edition 2017
SEMESTER-VI
REAL ANALYSIS –II

CODE: MMC1631
Instructional hours per week: 5
No. of credits: 4

Course Outcomes: At the end of Course, the Student will be able to:

CO-1. Understand various version of definition of limits and continuity of real valued functions.
CO-2. Understand the discontinuity criterion, uniform continuity, the intermediate value theorem and Monotone functions
CO-3. Understand the definition of differentiability of functions and learn differentiability implies continuity.
CO-4. Learn certain important theorems connecting differentiability of a function.
CO-5. Learn Riemann integration.

In the second part of the Real Analysis course, we focus on functions on R, their continuity, existence of derivatives, and integrability. The course is mainly based on Chapters 4, 5 and 7 of text[1].

All the chapters mentioned above contains a section titled Discussions in the beginning of the chapter. These sections are intended only for motivating the students, and so should not be made a part of the examination process.

Module-I (35 Hours)
Here we move towards the basic notion of limits of functions and their continuity. Various version of definition of limits are to be discussed here. The algebra of limits of functions and the divergence criterion for functional limits are to be discussed next. The other topics to be discussed in this module are the discontinuity criterion, composition of functions and continuity, continuity and compact sets, results on uniform continuity, the intermediate value theorem, Monotone functions and their continuity.

The topics to be discussed in this module can be found in chapter 4 of text[1] below. The first section 4.1 may be briefly discussed and is not meant for examination purposes. The subsection Preservation of connected sets may be omitted.

Module-II (25hours)
Here we discuss the derivative concept more rigorously than what was done in the previous calculus courses. After (re)introducing the definition of differentiability of functions, we verify that differentiability implies continuity. Algebra and composing of differentiable functions should be discussed next. The interior extremum theorem and Darboux’s theorem should be discussed after that. The mean value theorems should be discussed and proved, and the module ends with L’Hospitals results. A continuous everywhere but nowhere differentiable function should be discussed, but it is not meant for the examination. It may be in fact used for student seminars.

The topics to be discussed in this module can be found in chapter 5 of text [1] below. The sections 5.1 and 5.4 may be briefly discussed and is not meant for examination purposes.

Module-III (30 hours)
In the last module, the theory of Riemann integration is to be discussed. Main topics to be included in this module are defining the Riemann integral using upper, lower Riemann sums, and the integrability criterion, continuity and the existence of integral, algebraic
operations on integrable functions. (The results and examples on convergence of sequence of functions and integrability may be omitted), the fundamental theorem of calculus and its proof, Lebesgue's criterion for Riemann integrability.

The topics to be discussed in this module can be found in chapter 7 of text [1] below. The first section 7.1 may be briefly discussed and is not meant for examination purposes.

**Texts**


**References**

Ref. 1 – R G Bartle, D Sherbert; *Introduction to real analysis*, 3rd Edition, John Wiley & Sons


Ref. 3 – Terrence Tao; *Analysis I*, Hindustan Book Agency
COMPLEX ANALYSIS –II

Code: MMC 1632  Instructional hours per week: 4
No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to-

CO-1. Learn the well-known Cauchy's Integral Theorem.
CO-2. Learn the Cauchy's Integral formula
CO-4. Learn the Residue Theory of Complex functions.

Module-I  (32 Hours)
Series Representations for Analytic Functions : Sequences and Series, Taylor Series, Power Series, Mathematical Theory of Convergence, Laurent series, Zeros and Singularities. The point at Infinity. The topics to be discussed in this module can be found in chapter 5, sections 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7 of text [1] below.

Module-II  (20 Hours)
Residue Theory: The Residue Theorem, Trigonometric Integrals over $[0, 2\pi]$, Improper integrals of Certain functions over $[-\infty, \infty]$, Improper integrals involving Trigonometric Functions, Indented Contours. The topics to be discussed in this module can be found in chapter 6, sections 6.1, 6.2, 6.3, 6.4, 6.5 of text [1] below.

Module III  (20 Hours)
Conformal Mapping: Geometric Considerations, Mobius Transformations The topics to be discussed in this module can be found in chapter 7, sections 7.2, 7.3, 7.4 of text [1] below.

Texts


References

Ref.2– Murray R Spiegel. Complex variables: with an introduction to conformal mapping and its applications, Schaum’s outline.
GRAPH THEORY (ELECTIVE)

CODE: MMC1633.1 Instructional hours per week: 4
No. of credits: 3

Course Outcomes: At the end of the Course, the student will be able to:

- CO-1. Understand the role of graphs in Mathematics, Other branches of Science and Social Sciences.
- CO-2. Familiarize with many graphical parameters.
- CO-3. Explain different properties of graphs and in particular about trees.
- CO-4. Able to construct models of real life problems.
- CO-5. Analyze various applications through graphs.

Overview of the Course: The course has been designed to build an awareness of some of the fundamental concepts in Graph Theory and to develop better understanding of the subject so as to use these ideas skillfully in solving real world problems.

Module-I (36 Hours)
Basics: The Definition of a Graph, Graphs as Mathematical Models, other basic concepts and definitions, Vertex Degrees, Subgraphs, Paths and Cycles, The Matrix Representation of Graphs, Fusing graphs (The fusion algorithm for connectedness need not be discussed).

Trees and Connectivity: Definitions and Simple Properties of trees, Bridges, Spanning Trees, Cut Vertices and Connectivity. The topics in this module can be found in Chapter1, Sections 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7 and 1.8, Chapter2, Sections 2.1, 2.2, 2.3 and 2.6 of text[1].

Module-II (36 Hours)
Euler Tours and Hamiltonian Cycles: Euler Tours (Fleury’s algorithm need not be discussed), The Chinese Postman Problem (Only Statement of the problem is to be discussed) Hamiltonian Graphs, The Travelling Salesman Problem (Only Statement of the problem is to be discussed, The Two-Optimal Algorithm and The Closest Insertion Algorithm need not be discussed) Planar Graphs: Plane and Planar Graphs, Euler’s Formula, The Platonic Bodies, Kuratowski’s Theorem (Without proof). The topics in this module can be found in Chapter3, Sections 3.1, 3.2, 3.3 and 3.4, Chapter 5, Sections 5.1, 5.2, 5.3 and 5.4 of text[1].

Texts
Text 1 – John Clark, Derek Allan Holton. A first look at Graph Theory, World Scientific.

References
Ref. 2 – V Balakrishnan. Graph Theory, Schaums Outline
LINEAR PROGRAMMING WITH SAGEMATH (ELECTIVE)

CODE: MMC 16332

Instructional hours per week: 4

No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to-

CO-1. Solve various types of problems by using Linear programming.
CO-2. Acquire knowledge on Optimization.
CO-3. Develop algorithms for linear programs.
CO-4. Analyze different types of solutions for Linear programming problems.
CO-5. Experience with various method to solve a linear programming problem.

This course is aimed at providing an introduction to linear programming and solving problems in it using very basic methods.

Note:
1. There should not be any problems to solve using the SageMath software in the End Semester Examination (ESE). The ESE should be based only on the theory and problems to be solved either manually or using a non-programmable scientific calculator.
2. Students may be permitted to use nonprogrammable scientific calculator in the end semester examination.
3. One of the internal evaluation examinations should be done using SageMath Software, as a practical examination.

Module-I (24 Hours)
This module is aimed at providing a strong introduction to various type of problems that can be solved via linear programming. Main topics in this module are the following: Introduction to linear programming through problems, basic underlying assumptions like Proportionality, Divisibility, Additivity, Certainty, more general problems, standard form of a linear program, conversion rules to arrive at such a form like Converting unrestricted variables, Converting inequality constraints, Converting maximization to minimization, their examples, standard linear programming terminology, examples on planning, transportation, assignment, workforce scheduling, portfolio optimization, Minimum Cost Flow Problem, Maximum Flow Problem. 
The topics to be discussed in this module can be found in chapter 1 of text [1] below.

Module-II (24 hours)
This module begins with the geometry of linear programming and later proceeds to the Fundamental Theorem of Linear Programming which is a basis for algorithm development for linear programs. The main topics in this module are the following: Geometry of the Feasible Set, graphically representing the solution space, hyperplane, polyhedron, polytope, convex sets, geometry of optimal solutions, geometric characterization of optimality, extreme points and basic feasible solutions, generating basic feasible solutions, resolution theorem, fundamental theorem linear programming. 
The topics to be discussed in this module can be found in chapter 2 of text [1] below.

Module-III (24 hours)
Here we introduce the simplex method, which is an important method to solve linear programming problems. The main topics in this module are the following:
Introducing the simplex method, examples, adjacent basic feasible solutions, checking optimality of a basic feasible solution, direction-step length theorem, its application in developing the steps of simplex method, examples, finite termination under non-degeneracy, generating an initial basic feasible solution using two phase and Big M method, degeneracy and cycling, anti-cycling rules like Bland’s rule, and lexico graphic rules.

The topics to be discussed in this module can be found in chapter 3 of text [1] below.

All the problems in this course should be computationally also solved using the software SageMath. The references provided below, especially text[2] and chapter 4 of text[3] can be used mainly for this.

Texts


References


NUMERICAL ANALYSIS WITH SAGEMATH (ELECTIVE)

CODE: MMC 1633.3 Instructional hours per week: 4  
No. of credits: 3

Course Outcomes: At the end of the Course, the Student is able to-

CO-1. Familiar with getting approximate solutions to problems.
CO-3. Understand the principle of error and approximation.
CO-4. Analyze various methods and formula for solving equations \( f(x) = 0 \).

This course is aimed at providing an introduction to Numerical analysis with particular emphasize to finding approximate solutions to problems like finding roots of equations, numerically evaluating differential and integral equations, finding polynomials from values that approximate a given function, solving systems of linear equations etc. SageMath can be used as the software for supporting computations.

Note:
1. There should not be any problems to solve using the SageMath software in the End Semester Examination (ESE). The ESE should be based only on the theory and problems to be solved either manually or using a non-programmable scientific calculator.
2. Students may be permitted to use non-programmable scientific calculator in the end semester examination.
3. One of the internal evaluation examinations should be done using SageMath Software, as a practical examination.

Module I (36 Hours)

Solution of Equations by Iteration: Fixed-Point Iteration for Solving Equations \( f(x) = 0 \), Newton’s Method for Solving Equations \( f(x) = 0 \), Order of an Iteration Method Speed of Convergence, Convergence of Newton’s Method, Secant Method for Solving \( f(x) = 0 \).
Interpolation: Lagrange Interpolation, Newton’s Divided Difference Interpolation, Equal Spacing: Newton’s Forward Difference Formula, Equal Spacing: Newton’s Backward Difference Formula, Spline Interpolation,

The topics to be discussed in this module can be found in chapter 19, sections 19.1, 19.2, 19.3, 19.4 of text [1] below.

Module II (36 hours)
Numerical Integration and Differentiation: Rectangular Rule, Trapezoidal Rule, Simpson’s Rule of Integration, Adaptive Integration, Gauss Integration Formulas Maximum Degree of Precision, Numeric Differentiation.
Numerical Methods for Ordinary Differential Equations: Methods for First-Order ODEs, Picard’s Iteration Method, Euler’s method (Numeric Method), Improved Euler Method, Runge-Kutta Methods (RK Methods) off our the order.
Iteration Method, Jacobi Iteration

The topics to be discussed in this module can be found in chapter 19 section 1.2 and Problem set 1.7 CASPROJECT.6, Chapter 19 Sections 19.5, Chapter 20, Sections 20.1, 20.2, 20.3, Chapter 21 Sections 21.1, of text [1] below.

All the problems in this course should be computationally also solved using the software SageMath. The references provided below, especially text[2] and chapter 4 of text[3]can be used mainly for this.

**Texts**


**References**


FUZZY MATHEMATICS (ELECTIVE)

CODE: MMC 1633.4 Instructional hours per week: 4
No. of credits: 3

Course Outcomes: At the end of the Course, the Student will be able to-

CO-1. Able to construct Fuzzy sets.
CO-2. Analyze the properties of Crisp sets and fuzzy sets.
CO-3. Understand different Operations on Fuzzy sets
CO-4. Familiar with Fuzzy relations.
CO-5. Able to identify the similarities and difference between fuzzy set factors and crisp set factors.

Module-I (24 hours)
FROM CRISP SETS TO FUZZY SETS: A PARADIGM SHIFT. Introduction-crispsets: an overview-fuzzy sets: basic types and basic concepts of fuzzy sets, Fuzzy sets versus crisp sets, Additional properties of cuts, Representation of fuzzy sets.

Module-II (24 hours)
OPERATIONS ON FUZZY SETS AND FUZZY ARITHMETIC: Operations on fuzzy sets-types of operations, fuzzy complements, fuzzy intersections, t-norms, fuzzy unions, t-conorms. Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals, Arithmetic operations on fuzzy numbers.

Module-III (24 hours)
FUZZY RELATIONS: Crisp versus fuzzy relations, projections and cylindric extensions, Binary fuzzy relations, Binary relations on a single set, Fuzzy equivalence relations. The topics to be discussed in this module can be found in

Chapter 1: Sections 1.1 to 1.4,
Chapter 2: Sections 2.1 and 2.2,
Chapter 3: Sections 3.1 to 3.4 (proof of theorems 3.7, 3.8, lemma 3.1, 3.2, theorems 3.11, 3.12, 3.13 need not be discussed)
Chapter 4: Sections 4.1 to 4.4
Chapter 5: Sections 5.1 to 5.5 of text [1] below.

Texts

References

INTEGRAL TRANSFORMS

**CODE:** MMC 1633.5

**Instructional hours per week:** 4

**No. of credits:** 3

Course Outcomes: At the end of the Course, the Student will be able to-

- CO-1. Understand the basic concepts in Laplace transform.
- CO-2. Analyze the relation between transforms and integrals.
- CO-3. Apply transforms to Nonhomogeneous Linear Ordinary differential equations.
- CO-4. Acquire knowledge on different forms of ODE’s.
- CO-5. Preliminary ideas about Fourier series and periodic functions.

After completing courses in ordinary differential equations and basic integral calculus, we see here some of its applications.

**Module-I**

(38 Hours)

Laplace Transforms: Laplace Transform. Linearity. First Shifting Theorem (s-Shifting), s− Shifting: Replacing s by s − a in the Transform, Existence and Uniqueness of Laplace Transforms, Transforms of Derivatives and Integrals. ODEs, Laplace Transform of the Integral of a Function, Differential Equations, Initial Value Problems. Unit Step Function (Heaviside Function), Second Shifting Theorem (t−Shifting) Time Shifting (t−Shifting): Replacing t by t − a in f (t), Short Impulses. Diracs Delta Function. Partial Fractions Convolution , Application to Nonhomogeneous Linear ODEs, Differentiation and Integration of Transforms, ODEs with Variable Coefficients, Integration of Transforms, Special Linear ODEs with Variable Coefficients, Systems of ODEs

*The topics to be discussed in this module can be found in sections 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7 of text [1] below.*

**Module-II**

(16 hours)


*The topics to be discussed in this module can be found in Sections 11.1, 11.2, of text [1] below.*

**Texts**


**References**

COURSE OUTCOMES: at the end of the Course, the Student will be able to -

| CO1  | Remember data communication fundamentals and types of connections |
| CO2  | Understand pros and cons of different transmission media |
| CO3  | Remember protocols and standards |
| CO4  | Understand different LAN standards |
| CO5  | Evaluate leaky bucket algorithm |
| CO6  | Understand File Transfer Protocol |

COURSE CONTENT


TEXT BOOK

1. Brijendra Singh, Data Communication and Computer Networks, 2/e, PHI 4.2

REFERENCES

DATAMINING TECHNIQUES

**CODE:** MMC1642  
**Instructional hours per week:** 3  
**No. of credits:** 3

**COURSE OUTCOMES:** at the end of the Course, the Student will be able to -

<table>
<thead>
<tr>
<th>No.</th>
<th>OUTCOMES</th>
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<tbody>
<tr>
<td>CO1</td>
<td>Remember types and application domains of datamining</td>
</tr>
<tr>
<td>CO2</td>
<td>Understand Data Pre-processing and Cleaning</td>
</tr>
<tr>
<td>CO3</td>
<td>Apply rule base in classification</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyse Apriori algorithm</td>
</tr>
<tr>
<td>CO5</td>
<td>Understand characteristics and types of cluster analysis</td>
</tr>
<tr>
<td>CO6</td>
<td>Create decision trees for classification</td>
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**COURSE CONTENT**

**Module 1: Overview:** Data, Information, Knowledge; Knowledge Discovery; Types of data for Mining; Application Domains; Data Mining Functionalities; Data Processing – Understanding Data, Pre-processing Data – Forms of Data Pre-processing, Data Cleaning (Definition and Phases only), Need of Data Integration, Steps in Data Transformation, Need of Data Reduction;

**Module 2: Data Warehouse:** Database Systems & Data Warehouses – Difference; Data Warehouse – Definition & Features; Multidimensional Data Model – Data Cubes ; OLAP (Definition and Functions only); Market Basket Analysis; Association Rule – Overview; Criteria for classifying Frequent Pattern Mining ; Mining Single Dimensional Boolean Association Rule – Apriori Algorithm;

**Module 3: Classification:** Classification vs Prediction; Issues; Use of Decision Trees for Classification; Bayesian Classification – Bayes’ Theorem, Naïve Bayesian Classifier; Lazy Learners - k–Nearest Neighbour Method; Rule-Based Classification – Using IF-THEN rules for classification.

**Module 4: Cluster Analysis:** Introduction & Requirements; Characteristics of Clustering Techniques; Types of Data in Cluster Analysis; Categories of Clustering- Partitioning Methods; Outlier Detection in Clustering.

**TEXT BOOK**
1. Sunitha Tiwari & Neha Chaudhary, Data Mining And Warehousing, Dhanpat Rai & Co

**REFERENCES**
1. Jiawei Han and Micheline Kamber, Data Mining Concepts and Techniques, Elsevier
2. Arun K Pujari, Data Mining Techniques, Universities Press
3. G.K Gupta, Introduction To Data Mining With Case Studies, PHI
1. AIM:
➢ To expose student to industry-standard project practices, through a real-life project work under time and deliverable constraints, applying the knowledge acquired through various courses.

2. OBJECTIVES:
✓ To provide an opportunity to apply the knowledge gained through various courses in solving a real life problem
✓ To provide an opportunity to practice different phases of software/system development life cycle
✓ To introduce the student to a professional environment and/or style typical of a global IT industry
✓ To provide an opportunity for structured team work and project management
✓ To provide an opportunity for effective, real-life, technical documentation
✓ To provide an opportunity to practice time, resource and person management.

3. PROJECT GUIDELINES
- Group Size – Maximum 3
- No. of records – No. of group members+ 1 (Department copy)
- Certificate should include the names of all members

The minimal phases for the project are: Project search, finalization and allocation, Investigation of system requirements, Data and Process Modelling, System Design, Program design, Program coding and unit testing, System integration, System implementation and acceptance testing.

3.1 Planning the Project: The Major Project is an involved Exercise which has to be planned well in advance. The topic should be chosen in Semester 5 itself. Related reading, training and discussions should start from semester 5 itself.

3.2 Selection of project work: A requirement for developing a computer based solution already exists and the different stages of system development life cycle is to be implemented successfully or select a project where a clear-cut requirement for developing a computer based solution may not be existing, but a possible utility for the same is conceived by the proposer.

3.3 Selection of Tools: No restrictions shall be placed on the students in the choice of platforms/tools/languages to be utilized for their project work, though open source is strongly recommended, wherever possible. No value shall be placed on the use of tools in the evaluation of the project.

3.4 Selection of Organisation & Guide: No restrictions shall be placed on the students in the choice of organization where project work may be done, in terms of locality, type (public/private) etc. It is the duty of the project coordinator to ensure that the Aim, Objectives and full project guidelines are communicated to the external organization. Students may also choose to do project in the college/institute (or partially in the college/institute and partially in an external organization), especially product-based work, but in such cases the supervisors must ensure that (i) industry practices are followed (ii) the students undertake a planned visit to an IT industry with international operations to make up for the loss of experience and (iii) the services of an external guide with industry experience is obtained.
3.5 Project Management: Head of the department should publish a list of students, projects topics, internal guide and external organization (if any) and teams agreed, before the end of semester 5. Changes in this list may be permitted for valid reasons and shall be considered favorably by Head of the department any time before commencement of the project.

3.6 Documentation: The following are the major guidelines: The final outer dimensions of the report shall be 21 cm X 30 cm. The colour of the flap cover shall be uniform. Only hard binding should be done, with title of the thesis and the words “<BRIEF TITLE> COMPUTER APPLCIATION Project Report 200...” displayed on the spine in 20point, Bold, Times New Roman, as in example below. In case the title is too long, a shorter version of it may be used (Like “Image Pro” instead of ”Image Pro – An Interactive Image Processing package”). It is highly recommended that Latex be used for documentation.

- The text of the report should be set in 12 pt, Times New Roman, Single Spaced.
- Headings should be set as follows: CHAPTER HEADINGS 20 pt, Times New Roman, Bold, All Caps, Centered.

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1. SECTION HEADINGS 12 pt, Times New Roman, Bold, All Caps, Left Adjusted.
1.1 Section Sub-headings 12 pt, Times New Roman, Bold, Left Adjusted.

Some general guidelines on documentation stylistics are:

- Double quotes and single quotes (“”, “) should be used only when essential. In most cases words put in quotes are better highlighted by setting them in italics. Eg: This process is known as “morphing”. This process is known as morphing.
- Page numbers shall be set at right hand top corner, paragraph indent shall be set as 3.
- Only single space need be left above a section or sub-section heading and no space may be left after them.
- Certificate should be in the format: “Certified that this report titled........................... is abonafide record of the project work done by Sri/Kum..................... under our supervision and guidance, towards partial fulfillment of the requirements for the award of the Degree of BSC (Mathematics and Computer Applications) [Double Main] degree of University of Kerala

2023

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Project report format
- Organizational overview (of the client organization, where applicable)
- Description of the present system
- Limitations of the present system
- The Proposed system- Its advantages and features
- Context diagram of the proposed system.
- Top level DFD of the proposed system with at least one additional level of Expansion
- Structure Chart of the System
- System flowchart
- Menu Tree
- Program List
- Files or tables (for DBMS projects) list. Class names to be entered for each file in OO systems.
- List of fields or attributes (for DBMS projects) in each file or table.
- Program – File table that shows the files/tables used by each program and the files are read, written to, updated, queried or reports were produced from them.
- Reports List with column headings and summary information for each report.
- System Coding and variable/file/table naming conventions
- System controls and standards
- Screen layouts for each data entry screen.
- Report formats for each report.

Program documentation is suggested on the following lines:
- Program id
- Program level run chart
- Program function Explanation
- Data entry screen (reproduced from system documentation).
- Report layout (reproduced from system documentations)
- Program level pseudocode or flowchart.
- Decision tables, decision trees, with English Explanation where necessary.
- Program listing
- Test data
- Test results.

3.7 Methodology: Wherever applicable, object oriented approach should be used for software development. The project report should generally contain details of the following steps (though students should not attempt to fit every kind of project into this format):
(a) Analysis
- Study of existing systems and its drawbacks (general)
- Understanding the functionalities of the system (detailed)
- Preparation of requirement
- Conduct of Feasibility study
- Identification of relevant Objects
- Abstraction of each object (attributed and methods)
- Relationship between objects
(b) Design
- Design of each subsystems
- Design of each classes
- Design of communications between objects
- Design of Algorithms for problem solving
- User interface Design
- Any other steps if necessary
(c) Coding and Implementation
(d) Testing
(e) Security, Backup and Recovery Mechanisms
(f) Online help and User Manuals
(g) Upgradability Possibilities

3.8 Project IPR & Utilization: The intellectual property rights in all project work done by the students shall vest with the University of Kerala, except in cases where some external organizations seek undertaking from students to concede IPR in all work done in their organization or under their guidance. Where possible, students should attempt to obtain at least a joint IPR for the University. In cases where project works are of public utility, students shall be asked to publish their work including source code and documentation, in so far as their rights are clear.