B. Sc. (Honours)  
Mathematics and Computing  
Semester I - VI
PANJAB UNIVERSITY, CHANDIGARH
OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR CHOICE BASED CREDIT SYSTEM B.S.C. (HONOURS) MATHEMATICS AND COMPUTING UNDER THE FRAMEWORK OF HONOURS SCHOOL SYSTEM (SEMESTER SYSTEM) EXAMINATION, 2020-2021

OBJECTIVE OF THE COURSE
The objective of the proposed course is to teach the concepts of Mathematics and Computer Applications. The syllabus pertaining to B.Sc. (Honours) Mathematics and Computing (6 Semesters) in the subject of Mathematics and Computing under Honours School Framework has been framed as per provision of the UGC module for CHOICE BASED CREDIT SYSTEM and demand of the academic environment. The syllabus contents are duly arranged unit wise and contents are included in such a manner so that due importance is given to requisite intellectual skills according to UGC module for CHOICE BASED CREDIT SYSTEM pertaining to B.Sc. (Honours) in Mathematics.

EVALUATION

1. There shall be one internal assessment examination of 20% of the total marks.
2. End-semester examination will be of 80% of the total marks.
3. Each practical examination shall be of 3 hours duration.

Pattern of end-semester question paper

1. Nine questions in all with equal weightage. The candidate will be asked to attempt five questions.
2. One compulsory question (consisting of short answer type questions) covering whole syllabus.
3. There will be no choice in this question.
4. The remaining eight questions will have Four Units comprising two questions from each unit.
5. Candidate will attempt one question from each unit and the compulsory question.
# Course Structure with Credit Details

## SEMESTER – I (26 Credits)

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of Course</th>
<th>Theory / Practical</th>
<th>Core</th>
<th>GE</th>
<th>DSE</th>
<th>SEC</th>
<th>AECC</th>
</tr>
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<tbody>
<tr>
<td>MATC-C1</td>
<td>Calculus</td>
<td>T+P</td>
<td>4+2</td>
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<tr>
<td>MATC-C2</td>
<td>Algebra</td>
<td>T</td>
<td>6</td>
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<tr>
<td>MATC-C3</td>
<td>Fundamentals of Computers and Fortran - 90</td>
<td>T+P</td>
<td>4+2</td>
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## SEMESTER – II (26 Credits)

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<th>DSE</th>
<th>SEC</th>
<th>AECC</th>
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<tbody>
<tr>
<td>MATC-C4</td>
<td>Real Analysis</td>
<td>T</td>
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<tr>
<td>MATC-C5</td>
<td>Differential Equations</td>
<td>T+P</td>
<td>4+2</td>
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<tr>
<td>MATC-C6</td>
<td>Programming with C</td>
<td>T+P</td>
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<td>MATC-AECC2</td>
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## SEMESTER – III (30 Credits)

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<tbody>
<tr>
<td>MATC-C7</td>
<td>Group Theory I</td>
<td>T</td>
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<tr>
<td>MATC-C8</td>
<td>Data and File Structures</td>
<td>T+P</td>
<td>4+2</td>
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<tr>
<td>MATC-C9</td>
<td>Theory of Real Functions</td>
<td>T</td>
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<tr>
<td>MATC-SEC1</td>
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## SEMESTER – IV (30 Credits)

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<tbody>
<tr>
<td>MATC-C10</td>
<td>Ring Theory and Linear Algebra I</td>
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<tr>
<td>MATC-C11</td>
<td>Programming with Python</td>
<td>T+P</td>
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<tr>
<td>MATC-C12</td>
<td>Riemann Integration and series of Functions</td>
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<td>MATC-SEC2</td>
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<td>MATC-GE4</td>
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## SEMESTER – V (24 Credits)

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<td>MATC-C13</td>
<td>Probability and Statistics</td>
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<td>MATC-C14</td>
<td>Artificial Intelligence</td>
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<td>MATC-DSE2</td>
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## SEMESTER – VI (20 Credits)

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<tbody>
<tr>
<td>MATC-C15</td>
<td>Data Analytics Using R</td>
<td>T+P</td>
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<tr>
<td>MATC-C16</td>
<td>Numerical Optimization</td>
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<td>MATC-DSE3*</td>
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<td>MATC-DSE4</td>
<td>Research Project</td>
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Total Credits for B.Sc. (Honours) Mathematics and Computing will be 156 credits
(Core: 96 credits, GE: 24 credits, DSE: 20 credits, SEC: 12 credits, AECC: 4 credits)
## Nature of Courses

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name</th>
<th>Semester</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Core Courses (C) (MATC-C1 to MATC-C16)</td>
<td>I, II, III, IV, V, and VI</td>
<td>Each student of B.Sc. (Honours) Mathematics and Computing will be offered sixteen core courses (6 credits) over six semesters.</td>
</tr>
<tr>
<td>2.</td>
<td>Ability Enhancement Compulsory Course (AECC) (MATC-AECC1 to MATC-AECC2)</td>
<td>I and II</td>
<td>Each student of B.Sc. (Honours) Mathematics and Computing has to opt one AECC course in Semester - I and II out of the following: 1. English Communication (2 credits) 2. Environmental Science (2 credits)</td>
</tr>
<tr>
<td>3.</td>
<td>Generic Elective Courses (GE) (MATC-GE1 to MATC-GE4)</td>
<td>I, II, III, and IV</td>
<td>Each student of B.Sc. (Honours) Mathematics and Computing has to opt any one GE course (6 credit) offered by the other Departments of Panjab University for Semester I to IV.</td>
</tr>
<tr>
<td>4.</td>
<td>Skill Enhancement Courses (SEC) (MATC-SEC1 to MATC-SEC2)</td>
<td>III and IV</td>
<td>MATC-SEC1: Each student of B.Sc. (Honours) Mathematics and Computing has to opt any one SEC course (6 credit) out of the following. 1. PDE and system of ODE (P) (6 credit) 2. Discrete Mathematics (6 credit) MATC-SEC2: Each student of B.Sc. (Honours) Mathematics and Computing has to opt for the course: Numerical Methods (P) (6 credit).</td>
</tr>
<tr>
<td>5.</td>
<td>Discipline Specific Elective Courses* (DSE*) (MATC-DES1* and MATC-DES3*)</td>
<td>V and VI</td>
<td>MATC-DSE1*: Each student of B.Sc. (Honours) Mathematics and Computing has to opt for the course: Group Theory II (6 credit). MATC-DSE3*: Each student of B.Sc. (Honours) Mathematics and Computing has to opt for the course: Ring Theory and Linear Algebra II (6 credit).</td>
</tr>
<tr>
<td>6.</td>
<td>Discipline Specific Elective Courses (DSE) (MATC-DES2 and MATC-DES4)</td>
<td>V and VI</td>
<td>MATC-DSE2: Each student of B.Sc. (Honours) Mathematics and Computing has to opt any one DSE course out of the following. 1. Multivariate Calculus (6 credit). 2. Number Theory (6 credit). MATC-DSE4: Each student of B.Sc. (Honours) Mathematics and Computing will be given a Research Project (RP), either individually or in a group of 2-3 students. This research project will be of 2 credits.</td>
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</tbody>
</table>
Note:

1. The Academic Committee of the department will appoint one viva-voce committee which will formulate the guidelines related to the following points:
   (a) Assigning supervisor to the student or group of students.
   (b) Starting time of Research project (RP).
   (c) Duration of the Research Project (RP).
   (d) Format to be adopted for the Research Project (RP) report which includes declaration by the student.
   (e) Format to be adopted for the visual presentation.
   (f) Procedure for evaluating the research project.
   (g) Project report should not contain verbatim reproduction of material available elsewhere. Requirement of plagiarism certificate.
   (h) Any copyright issue.
   (i) Preserving a proper copy (soft copy) of the student’s report for archiving and cataloguing it in the Departmental Library, making it available to others for academic purpose.

2. Each of Core, Generic Elective and Discipline Specific Elective subjects consists of 60 lectures, which consists of (i) 48 contact hours of teaching to be delivered exclusively by the teacher as per the scheduled time-table and (ii) 12 hours for the interaction, discussion, assignments and seminars (attended/delivered) by the students.
MATC - C1: CALCULUS (THEORY) (4 credits)

Total Lectures: 40 4 hrs. per week
Max. Marks: 100 (Final-80+Internal Assessment-20) Time allowed: 3hrs.

The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
There will be two questions from each unit and the students will be required to answer one question from each unit.
All questions carry equal marks.

**Objective:** The main goal of this course is to deliver the basics of differential and integral calculus, for real as well as multivariate functions. It is expected that the students develop a taste of writing proofs, particularly for Unit I, rather than applying formulas only.

**Unit I  Differential Calculus**
Precise definition of limit, continuity, one-sided limit, limits involving infinity, asymptotes of graphs, tangents and the derivative at a point, the derivative of a function, extreme values of functions, mean value theorem, monotone functions and the first derivative test, test for concavity, tracing of curves.
(Scope: Sections 2.3 – 2.6, 3.1, 3.2, 4.1 –4.4 of [1]).

**Unit II  Integral Calculus**
Riemann sums, definite integrals, area between curves, volumes using cross sections and cylindrical shells, arc length and areas of surfaces of revolution.
(Scope: Sections 5.1, 5.6, 6.1 – 6.4 of [1]).

**Unit III  Multivariable Functions**
Limits and continuity for functions of several variables, partial derivatives, the chain rule, directional derivatives, gradient vectors, tangent planes, extreme values and saddle points, Lagrange multipliers.
(Scope: Sections 14.2 – 14.8 of [1]).

**Unit IV  Multiple Integrals**
Double integrals, triple integrals, Jacobian, substitutions in multiple integrals, Green’s theorem, Stoke’s theorem and the divergence’s theorem.
(Scope: Relevant sections of Chapters 15, 16 of [1]).

**Books Recommended**
MATC - C1: CALCULUS (PRACTICAL) (2 credits)

Using any software

Total Lectures: 20  
3 practical per week in a groups of 15 students
Max. Marks: 50 (Final-40+Internal Assessment-10)  
Time allowed: 3hrs.

→ The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
→ There will be two questions from each unit and the students will be required to answer one question from each unit.
→ All questions carry equal marks.

Objective: The main goal of this course is to deliver the basics of differential and integral calculus, for real as well as multivariate functions. It is expected that the students develop a taste of writing proofs, particularly for Unit I, rather than applying formulas only.

List of Practicals:

a) Matrix operations (addition, multiplication, inverse, transpose, determinant and rank).
b) Plotting of graphs of polynomials of degree 4 and 5, the derivative graph, the the second derivative graph and comparing them.
c) Plotting functions $e^{ax} + b$, $\log(ax + b)$, $1/(ax + b)$, $\sin(ax + b)$, $\cos(ax + b)$, $|ax + b|$ and to illustrate the effect of $a$ and $b$ on the graph.
d) Obtaining surfaces of revolution of curves.
e) Tracing of conics in Cartesian coordinates/ polar coordinates.
f) 3D plots.
g) Computation of limits, derivatives and integration of vector functions.
h) Tangent planes to surfaces at a given point.
i) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using Cartesian coordinates.

Books Recommended

MATC – C2: ALGEBRA (THEORY) (6 credits)

Total Lectures: 60  
Max. Marks: 150 (Final-120+Internal Assessment-30)  
6 hrs / per week  
Time allowed: 3hrs.

The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.

There will be two questions from each unit and the students will be required to answer one question from each unit.

All questions carry equal marks.

Objective: The concepts and techniques from linear algebra are of fundamental importance in many scientific disciplines. The main objective is to introduce basic notions in linear algebra that are often used in mathematics and other sciences. The emphasis will be to combine the abstract concepts with examples in order to intensify the understanding of the subject.

Unit I  
Review of system of linear equations, general theory of system of linear equations, n-dimensional vector space, linear dependence, rank of a matrix, system of homogeneous and non-homogeneous linear equations, an axiomatic construction of theory of determinants.  
(Scope as in chapters 1, 2, 3 of [1])

Unit II  
A deeper look at Complex Numbers, taking roots of complex numbers, quick review of operations on polynomials, divisors and greatest common divisor, roots of polynomials, fundamental theorem, corollaries of fundamental theorem, rational fractions.  
(Scope as in chapters 4 and 5 of [1])

Unit III  
Evaluating roots of polynomials of third and fourth degree, bounds of roots, sturm’s theorem, other theorems on the number of real roots, approximation of roots.  
(Scope as in chapter 9 of [1])

Unit IV  
Definition of a linear space, an isomorphism, finite dimensional spaces, bases, linear transformation linear subspaces, characteristic roots and eigen values.  
(Scope as in chapter 2 of [6])

Books Recommended

1. Kurosh, Higher Algebra, MIR Moscow, 1982
MATC – C3: FUNDAMENTALS OF COMPUTERS AND FORTRAN – 90
(THEORY) (4 credits)

Total Lectures: 40 4 hrs / per week
Max. Marks: 100 (Final-80+Internal Assessment-20) Time allowed: 3hrs.

The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.

There will be two questions from each unit and the students will be required to answer one question from each unit.

All questions carry equal marks.

Objective: This course provides an introduction to the Fortran 90 programming language. It should provide you with enough knowledge to write straightforward FORTRAN programs and you should also gain some general experience which can usefully be applied when using any programming language.

Unit I  Programmable model of Computer, Components of Computer System, Central Processing Unit (CPU), VDU, Keyboard and Mouse, Other input/output Devices, Computer Memory, Concepts of Hardware and Software; Concept of Computing, Data and Information; Applications of IECT; Peripheral Devices.
Classification of Programming Languages: Machine Language (Low-level language), Assembly Language, High-level language, Algorithms and Flowcharts.

Unit II Numerical Constants and Variables: Constants, Scalar variables, declaring variable names, Implicit declaration, Named constants; Arithmetic expressions: Arithmetic operators, Integer expressions, real expressions, precedence of operations in expressions, assigning statements, defining variables, mixed mode expressions.

Unit III Intrinsic functions and its use; List directed input and output statements; conditional statements, DO Loop, Logical expressions; rules for logical operators and use of logical expressions; Basics of Functions and Subroutines; Defining and Manipulating Arrays and use of Arrays in DO Loop.

Unit IV Elementary Format specifications; Processing strings of characters; Procedures with array arguments: Derived types: Additional features in procedures; Processing files in Fortran; Pointer data types and applications; Use of modules and Miscellaneous features of Fortran 90.

Books Recommended
MATC – C3: FUNDAMENTALS OF COMPUTERS AND FORTRAN – 90
(PRACTICAL) (2 credits)

Total Lectures: 20  
3 practical per week in a groups of 15 students
Max. Marks: 50 (Final-40+Internal Assessment-10)  
Time allowed: 3hrs.

→ The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
→ There will be two questions from each unit and the students will be required to answer one question from each unit.
→ All questions carry equal marks.

Objective: This course provides an introduction to the Fortran 90 programming language. It should provide you with enough knowledge to write straightforward FORTRAN programs and you should also gain some general experience which can usefully be applied when using any programming language.

List of practicals:

(a) Practical 1: Simple programs to compute Simple interest, Compound interest, Area of triangle, circle, ellipse etc.
(b) Practical 2: Roots of quadratic equation, Curved surface area of two joint objects, e.g. Cylinder and Cone etc.
(c) Practical 3: Sum of first n natural numbers, Sum of squares and cubes of first n natural numbers.
(d) Practical 4: To verify \( \sin x \approx x \) for small value of \( x \).
(e) Practical 5: Calculate Salary of employed persons using DO loop
(f) Practical 6: Arrange the random numbers in ascending/descending order.

Books Recommended

MATC – C4: REAL ANALYSIS (THEORY) (6 credits)

Total Lectures: 60  
Max. Marks: 150 (Final-120+Internal Assessment-30)  
Time allowed: 3hrs.

The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.

There will be two questions from each unit and the students will be required to answer one question from each unit.

All questions carry equal marks.

Objective: Introduction to the cardinality of sets, completeness property of real numbers, sequences and series of real numbers and the limit and continuity of real functions.

Unit I  
Finite and infinite sets, countable and uncountable sets, Cantor’s theorem, Schroder-Bernstein theorem, the Cantor set, the completeness property of reals, applications of the supremum property, the Archimedean property, density of rational numbers in reals, intervals, decimal and general expansions of reals.

(Scope: Sections 1.3, 2.3, 2.4, 2.5 of [1] and pages 24-29 of [2].)

Unit II  
Sequence and their limits, limits theorems, monotone sequences, subsequences and the Bolzano-Weierstrass theorem, monotone subsequence theorem, the Cauchy criterion, the Cantor nested interval theorem, divergence of a sequence.

(Scope: Sections 3.1 to 3.6 of [1].)

Unit III  
Limit of a function (epsilon-delta approach) and limit theorems, continuous functions, combinations of continuous functions, extensions of the limit concept, continuous functions on intervals, monotone functions and inverse functions.

(Scope: Sections 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 5.6 of [1].)

Unit IV  
Introduction to infinite series, absolute convergence of infinite series, tests for absolute convergence, tests for non-absolute convergence of a series.

(Scope: Sections 3.7, 9.1, 9.2, 9.3 of [1].)

Books Recommended

MATC – C5: DIFFERENTIAL EQUATIONS (THEORY) (4 credits)

Total Lectures: 40  
Max. Marks: 100 (Final-80+Internal Assessment-20)  
Time allowed: 3hrs.

→ The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
→ There will be two questions from each unit and the students will be required to answer one question from each unit.
→ All questions carry equal marks.

Objective: To exhibit the techniques for obtaining solutions to ordinary differential equations and the basic ideas and theory behind those techniques.

Unit I Classification of Differential Equations: Their Origin and applications. Nature and method of solutions. Initial and boundary value problem. Existence and uniqueness theorem. (Scope as in Chapter 1 of Ref. [3]). Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. Clairaut equation. (Scope as in Chapter 2 of Ref. [3])

Unit II Applications of First Order Equations: Orthogonal and oblique trajectories. (Scope as in Chapter 3 of Ref. [3]), Higher-Order Linear Differential Equations: Basic Existence Theorem, The Homogeneous Equation, Wronskian, its properties and applications. Reduction of order, thenon-homogeneous equation, the homogeneous linear equation with constant coefficients, initial-value problem, the Cauchy-Euler equation, theorems on the second-order homogeneous linear equation. (Scope as in Chapter 4 of Ref. [3])

Unit III The method of undetermined coefficients, method of variation of parameters, basic properties of the Laplace transform, the inverse Laplace transform, Solving IVP's with Laplace transforms.

Unit IV Ordinary points and singular points, power series solution about an ordinary point, power series solution about singular points, The method of Frobenius. Bessel equation, Legendre equation, Hermite equation, Bessel function and their recurrence relations (Scope as in Chapter 6 of Ref. [3]).

Books Recommended
MATC – C5: DIFFERENTIAL EQUATIONS (PRACTICAL) (2 credits)

Total Lectures: 20
Max. Marks: 50 (Final-40+Internal Assessment-10)

3 practical per week in a groups of 15 students
Time allowed: 3hrs.

The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
There will be two questions from each unit and the students will be required to answer one question from each unit.
All questions carry equal marks.

Objective: To exhibit the techniques for obtaining solutions to ordinary differential equations and the basic ideas and theory behind those techniques.

List of practicals:

a) Plotting and finding solution of first order differential equation.
b) Plotting and finding solution of second order differential equation.
c) Plotting and finding solution of third order differential equation.
d) Solution of initial value problems
e) Solution of boundary value problem.
f) Exponential growth model.
g) Exponential decay model.
h) Limited growth of population
i) Orthogonal and Oblique Trajectories
j) Solution of ODE by Reduction of order.
k) Power series solution and matching with exact solution.

Books Recommended

MATC – C6: PROGRAMMING WITH C (THEORY) (4 credits)

Total Lectures: 40  4 hrs. per week
Max. Marks: 100 (Final-80+Internal Assessment-20)  Time allowed: 3hrs.

→ The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
→ There will be two questions from each unit and the students will be required to answer one question from each unit.
→ All questions carry equal marks.

Objective: The objective of this syllabus is to teach computer fundamentals and introduction to ‘C’ Language. This will help students to learn about functioning of computers and familiarity with computer Language ‘C’.

Unit I
Introduction to C language: Character set, constants and variables, Operators: arithmetic, relational and logical, Conditional operators, precedence and order of evaluation. Decision control structure, if, if-else, nested if-else, loops, while and for loops.

Unit II
Break and do-while loops, switch and case control structure. Functions and storage classes in C: Introduction and Writing Functions, Scope of Variables, Storage Classes, Passing values between functions and Recursion. Call by value and call by reference.

Unit III
Arrays: declaring an array, initializing an array. Passing array elements to a function, One dimensional array: array manipulation; searching, insertion, deletion of an element from an array; Finding the largest/smallest element in array: two dimensional arrays, addition/multiplication of two matrices, transpose of a square matrix; null terminated strings as array of characters.

Unit IV
Finding the largest/smallest element in array: two dimensional arrays, addition/multiplication of two matrices, transpose of a square matrix; null terminated strings as array of characters.

Books Recommended
MATC – C6: PROGRAMMING WITH C (PRACTICAL) (2 credits)
Total Lectures: 20 3 practical per week in a groups of 15 students
Max. Marks: 50 (Final-40+Internal Assessment-10)  Time allowed: 3hrs.

→ The question paper will have nine questions. Question No.1 spread over the whole syllabus will be compulsory. Candidates will attempt five questions.
→ There will be two questions from each unit and the students will be required to answer one question from each unit.
→ All questions carry equal marks.

Objective: The objective of this syllabus is to teach computer fundamentals and introduction to ‘C’ Language. This will help students to learn about functioning of computers and familiarity with computer Language ‘C’.

Instructions: Teacher will prepare assignment sheets of the topics mention below:

List of practicals:

a) Topics: basics -- simple example programs
b) Topics: Using data types and constants; variables, identifiers, and declarations; operators and expressions.
c) Topics: Using arrays, more about declarations (incl. initialization), functions
d) Topics: Using assignment, increment, and decrement operators; character I/O; strings
e) Topics: Using pointers, strings
f) Topics: Using array/pointer equivalence, memory allocation, more about strings

Books Recommended