SEMESTER SYSTEM COURSE STRUCTURE
(CHOICE BASED CREDIT)

M. SC. COURSE IN MATHEMATICS
(PURE AND APPLIED STREAMS)

DEPARTMENT OF MATHEMATICS
FACULTY OF SCIENCE
UNIVERSITY OF KALYANI

Date: 21/04/2017
M. Sc. Course in Mathematics  
(Pure and Applied Streams)  
Total Marks : 1600  
(Total four semester course carrying 400 marks in each semester)

Outline of the Choice Based Credit Semester System

Transaction Categories:  
C: Common to both Streams;  
A: Applied Stream;  
P: Pure Stream;  
CB: Choice Based Course;  
O: Optional Subject;  
PW: Project Work

Evaluation Categories:  
SEE: Semester End Examination;  
IA: Internal Assessment

<table>
<thead>
<tr>
<th>Course</th>
<th>Topics</th>
<th>Marks</th>
<th>Credit</th>
<th>Hrs./Wk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SEE</td>
<td>IA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEMESTER I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATC 1.1</td>
<td>Real Analysis – I ; Complex Analysis – I ; Functional Analysis – I</td>
<td>80</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>MATC 1.2</td>
<td>Ordinary Differential Equations ; Partial Differential Equations</td>
<td>80</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>MATC 1.3</td>
<td>Mechanics – I ; Abstract Algebra – I ; Operations Research–I</td>
<td>80</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td><strong>MATC 1.1 TO MATC 1.3 ARE COMMON TO BOTH PURE AND APPLIED STREAMS</strong></td>
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<tr>
<td>MATA 1.4</td>
<td>Mechanics of Solids ; Non-linear Dynamics</td>
<td>80</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>MATP 1.4</td>
<td>Differential Geometry–I ; Topology–I</td>
<td>80</td>
<td>20</td>
<td>4</td>
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<tr>
<td>SEMESTER II</td>
<td></td>
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</tr>
<tr>
<td>MATCB 2.1</td>
<td>History of Mathematics ; Operations Research ; Linear Algebra ; Dynamical Systems</td>
<td>80</td>
<td>20</td>
<td>4</td>
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<tr>
<td><strong>MATCB 2.1 IS BASED ON THE CHOICES OF THE STUDENTS OF OTHER DEPARTMENT(S)</strong></td>
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<tr>
<td>MATC 2.2</td>
<td>Real Analysis – II ; Complex Analysis – II ; Functional Analysis – II</td>
<td>80</td>
<td>20</td>
<td>4</td>
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<tr>
<td>MATC 2.3</td>
<td>Mechanics – II ; Abstract Algebra– II ; Operations Research –II</td>
<td>80</td>
<td>20</td>
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<tr>
<td><strong>MATC 2.2 TO MATC 2.3 ARE COMMON TO BOTH PURE AND APPLIED STREAMS</strong></td>
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</tr>
<tr>
<td>MATA 2.4</td>
<td>Mechanics of Fluids ; Stochastic Process</td>
<td>80</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>MATP 2.4</td>
<td>Differential Geometry–II ; Topology–II</td>
<td>80</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>SEMESTER III</td>
<td></td>
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</tr>
<tr>
<td>MATC 3.1</td>
<td>Linear Algebra ; Special Functions ; Integral Equations &amp; Integral Transforms</td>
<td>80</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td><strong>MATC 3.1 TO MATC 3.2 ARE COMMON TO BOTH PURE AND APPLIED STREAMS</strong></td>
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<table>
<thead>
<tr>
<th>Course</th>
<th>Topics</th>
<th>Marks</th>
<th>Credit</th>
<th>Hrs./Wk</th>
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</thead>
<tbody>
<tr>
<td>SEMESTER III (Contd..)</td>
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</tr>
<tr>
<td>MATA 3.2</td>
<td>Fuzzy Set Theory ; Computer Programming in ‘C’ (Theory); Numerical Analysis (Practical)</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>MATA 3.3</td>
<td>Dynamical System ; Numerical Analysis (Theory)</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>MATA 3.4</td>
<td>Mathematical Biology ; Electro Magnetic Theory</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>MATP 3.2</td>
<td>Fuzzy Set Theory ; Computer Programming in ‘C’ (Theory); Computer Programming in ‘C’ (Practical)</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>MATP 3.3</td>
<td>Topological Groups ; Measure Theory</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>MATP 3.4</td>
<td>Calculus of $R^n$ + Operator Theory</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>SEMESTER IV</td>
<td></td>
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</tr>
<tr>
<td>MATC 4.1</td>
<td>Discrete Mathematics ; Probability and Statistical Methods</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>MATC 4.1</td>
<td>IS COMMON TO BOTH PURE AND APPLIED STREAMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATO 4.2</td>
<td>Optional Paper – I</td>
<td>80</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>MATO 4.3</td>
<td>Optional Paper – II</td>
<td>80</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

The Optional Papers be offered to the students on the basis of availability of Teachers and within the Framed Syllabi of the Optional Papers

<table>
<thead>
<tr>
<th>Course</th>
<th>Topics</th>
<th>Dissertation</th>
<th>Presentation</th>
<th>Viva Voce</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATPW 4.4</td>
<td>Project Work</td>
<td>50</td>
<td>30</td>
<td>20</td>
<td>4</td>
</tr>
</tbody>
</table>

Each student has to undergo through a Project Work under the guidance of the teacher(s) of the Department, and on the basis of subject interest of the students in advanced field of study in different areas of Mathematics.

(S. Pal)
The Head of the Department of Mathematics

Contd..
## Semester-Wise Distribution of Subjects with Marks

### I. First Semester:

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject-Wise Marks</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATC 1.1</td>
<td>Real Analysis – I + Complex Analysis – I + Functional Analysis – I</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>(SEE: 25+30+25; IA: 7+6+7)</td>
<td></td>
</tr>
<tr>
<td>MATC 1.2</td>
<td>Ordinary Differential Equations + Partial Differential Equations</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>(SEE: 40+40; IA: 10+10)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(SEE: 30+25+25; IA: 6+7+7)</td>
<td></td>
</tr>
</tbody>
</table>

*MATC 1.1 – MATC 1.3 are common to both the pure and applied streams.*

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject-Wise Marks</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATA 1.4</td>
<td>Mechanics of Solids + Non-linear Dynamics</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(Applied Stream)</em></td>
<td><em>(SEE: 40+40; IA: 10+10)</em></td>
</tr>
<tr>
<td>MATP 1.4</td>
<td>Differential Geometry–I + Topology–I</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(Pure Stream)</em></td>
<td><em>(SEE: 40+40; IA: 10+10)</em></td>
</tr>
</tbody>
</table>

### II. Second Semester:

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject-Wise Marks</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATCB 2.1</td>
<td>History of Mathematics + Operations Research + Linear Algebra + Dynamical Systems</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 20+20+20+20; IA: 5+5+5+5)</em></td>
<td></td>
</tr>
</tbody>
</table>

*MATCB 2.1 is based on the Choices of the Students of other Department(s)*

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject-Wise Marks</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATC 2.2</td>
<td>Real Analysis – II + Complex Analysis – II+ Functional Analysis – II</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 25+25+30; IA: 7+7+6)</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 25+25+30; IA: 7+7+6)</em></td>
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</tr>
</tbody>
</table>

*MATC 2.2 – MATC 2.3 are common to Both the Pure and Applied Streams Students.*

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject-Wise Marks</th>
<th>Total Marks</th>
</tr>
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<tbody>
<tr>
<td>MATA 2.4</td>
<td>Mechanics of Fluids + Stochastic Process</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(Applied Stream)</em></td>
<td><em>(SEE: 50+30; IA: 10+10)</em></td>
</tr>
<tr>
<td>MATP 2.4</td>
<td>Differential Geometry–II + Topology–II</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(Pure Stream)</em></td>
<td><em>(SEE: 40+40; IA: 10+10)</em></td>
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</tbody>
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(S. Pal)
The Head of the Department of Mathematics

Contd..
### III. Third Semester:

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATC 3.1:</td>
<td>Linear Algebra + Special Functions + Integral Equations &amp; Integral Transforms</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 30+20+30; IA: 10+5+5)</em></td>
<td></td>
</tr>
</tbody>
</table>

*MATC 3.1 is Compulsory to Both the Pure and Applied Streams Students.*

### APPLIED STREAM

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATA 3.2:</td>
<td>Fuzzy Set Theory + Computer Programming in ‘C’ (Theory) + Numerical Analysis (Practical)</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 20+30+30; IA: 6+7+7)</em></td>
<td></td>
</tr>
<tr>
<td>MATA 3.3:</td>
<td>Dynamical System + Numerical Analysis (Theory)</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 40+40; IA: 10+10)</em></td>
<td></td>
</tr>
<tr>
<td>MATA 3.4:</td>
<td>Mathematical Biology + Electro Magnetic Theory</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 55+25; IA: 15+5)</em></td>
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</tr>
</tbody>
</table>

### PURE STREAM

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATP 3.2:</td>
<td>Fuzzy Set Theory + Computer Programming in ‘C’ (Theory) + Computer Programming in ‘C’ (Practical)</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 20+30+30; IA: 6+7+7)</em></td>
<td></td>
</tr>
<tr>
<td>MATP 3.3:</td>
<td>Topological Groups + Measure Theory</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 40+40; IA: 10+10)</em></td>
<td></td>
</tr>
<tr>
<td>MATP 3.4:</td>
<td>Calculus of $\mathbb{R}^n$ + Operator Theory</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 40+40; IA: 10+10)</em></td>
<td></td>
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</tbody>
</table>

### IV. Fourth Semester:

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATC 4.1:</td>
<td>Discrete Mathematics + Probability and Statistical Methods</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><em>(SEE: 50+30; IA: 10+10)</em></td>
<td></td>
</tr>
</tbody>
</table>

*MATC 4.1 is common to Both the Pure and Applied Streams Students.*

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(S. Pal)  
The Head of the Department of Mathematics  
Contd..
*MATO 4.2 & MATO 4.3: Two Separate Optional Subjects with 100 Marks (SEE: 80; IA: 20) under each Course as Special Fields of Study.

(The Optional Subjects are listed in a Separate Sheet)

- The Optional Subjects be offered to the Students of both the Streams (Pure and Applied) on the basis of availability of Teachers as Resource Persons and within the Framed Syllabi of the Optional Subjects.

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Subject</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATPW 4.4:</td>
<td>Project Work</td>
<td>100</td>
</tr>
</tbody>
</table>

(Dissertation: 50 + Seminar presentation: 30 + Viva-voce: 20)

*MATPW 4.4 is Compulsory to Both the Pure and Applied Streams Students.

Examination Related Course Criteria (Unit 16):

(i) Project Work be made by the students under the guidance of the teacher(s) of the Department, and on the basis of subject interest of the students in advanced field of study in different areas of Mathematics.

(ii) Dissertation of the Project Work be prepared by individual student and the same be submitted to the HOD after countersigned by the concerned teacher(s) and prior to commencement of Viva-Voce.

(iii) Project Work related Record be maintained by the Department.

(iv) Seminar presentation and Viva–Voce Examination be conducted by the Department.

(S. Pal)
The Head of the Department of Mathematics

Contd..
The List of Optional Papers

<table>
<thead>
<tr>
<th>Applied Stream</th>
<th>Pure Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3. Fuzzy Sets and Systems</td>
<td>#3. Fuzzy Sets and Systems</td>
</tr>
<tr>
<td>10. Seismology</td>
<td>10. Abstract Harmonic Analysis</td>
</tr>
<tr>
<td>(Theory and Practical)</td>
<td>(Theory and Practical)</td>
</tr>
<tr>
<td>16. Compressible Fluid Dynamics</td>
<td>17. Ergodic Theory and Topological Dynamics</td>
</tr>
</tbody>
</table>

and Fuzzy Sets and Systems are common to both the Pure and Applied Streams*

(S. Pal)
The Head of the Department of Mathematics

Contd..
I. The First Semester

**MATC 1.1**
Real Analysis – I  
(Pure and Applied Streams)  
Marks : 32 (SEE: 25; IA: 07)

Cardinal number: Definition, Schröder-Berstein theorem, Order relation of cardinal numbers, Arithmetic of cardinal numbers, Continuum hypothesis  

Cantor’s set: Construction and its presentation as an uncountable set of measure zero  

Functions of bounded variation: Definition and basic properties, Lipschitz condition, Jordan decomposition, Nature of points of discontinuity, Nature of points of non-differentiability, Convergence in variation (Helly’s First theorem).  

Absolutely continuous functions: Definition and basic properties, Deduction of the class of all absolutely continuous functions as a proper subclass of all functions of bounded variation, Characterization of an absolutely continuous function in terms of its derivative vanishing almost everywhere.  

Riemann-Stieltjes integral: Existence and basic properties, Integration by parts, Integration of a continuous function with respect to a step function, Convergence theorems in respect of integrand, convergence theorem in respect of integrator (Helly’s Second theorem).  

Gauge partition: Definition of a delta-fine tagged partition and its existence, Lebesgue’s criterion for Riemann integrability, Delta-fine free tagged partition and an equivalent definition of the Riemann integral.

**References:**

3. H. L. Royden: Real Analysis.  
5. A. G. Das: The Generalized Riemann Integral.  
7. W. Sierpinsky: Cardinal Number and Ordinal Number.  

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(S. Pal)  
The Head of the Department of Mathematics  
Contd..
Complex Analysis – I  
(Pure and Applied Streams)  
Marks : 36 (SEE: 30; IA: 06)

Riemann’s sphere, point at infinity and the extended complex plane.  


References:
5. J. B. Conway: Functions of One Complex Variable.

Functional Analysis–I  
(Pure and Applied Streams)  
Marks : 32 (SEE: 25; IA: 07)

Metric spaces. Brief discussions of continuity, completeness, compactness. Hölder’s and Minkowski’s inequalities (statement only).  

Baire’s (category) theorem. The spaces $\mathbb{R}^k, C^k, C [a, b]$ and $\ell_p$. Banach’s fixed point theorem, applications to solutions of certain systems of linear algebraic equations, Fredholm’s integral equation of the second kind, implicit function theorem. Kannan’s fixed point theorem.

The Head of the Department of Mathematics

Contd..

References:

MATC 1.2
Ordinary Differential Equations
(Pure and Applied Streams)
Marks : 50 (SEE: 40; IA: 10)


Solution of linear ordinary differential equations of second order in complex domain. Existence of solutions near an ordinary point and a regular singular point, Solutions of Hyper geometric equation and Hermite equation, Introduction to special functions

References:

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Partial Differential Equations
(Pure and Applied Streams)
Marks : 50 (SEE: 40; IA: 10)


Parabolic equation, Initial and boundary conditions, Heat equation under Dirichlet’s Condition, Solution of Heat equation under Dirichlet’s Condition, Solution of Heat equation under Neuman Condition, Solution of Parabolic equation under non-homogeneous boundary condition. (9)

Hyperbolic equation, occurrence of wave equations, in Mathematical Physics, Initial and boundary conditions, Initial value problem, D’ Alembert’s solutions, vibration of a sting of finite length, Initial value problem for a non-homogeneous wave equation. (9)

Elliptic equations, Gauss Divergence Theorem, Green’s identities, Harmonic functions, Laplace equation in cylindrical and spherical polar coordinates, Dirichlet’s Problem, Neumann Problem, (9)

References :
MATC 1.3
Mechanics – I (Potential Theory)
(Pure and Applied Streams)
Marks : 36 (SEE: 30; IA: 06)

Concept of potential and attraction for line, surface and volume distributions of matter. Laplace’s equation, problems of attraction and potential for simple distribution of matter. (5)

Existence and continuity of first and second derivatives of potential within matter. Poisson’s equation, work done by mutual attraction, problems. (7)

Integral theorem of potential theory (statement only) Green’s identities, Gauss’ average value theorem, continuity of potential and discontinuity of normal derivative of potential for a surface distribution, potential for a single and double layer, Discontinuity of potential. (8)

Boundary value problems of potential theory. Green’s function, solution of Dirichlet’s problem for a half-space. (5)

Solid and surface spherical harmonics. (5)

References :

Abstract Algebra –I
(Pure and Applied Streams)
Marks : 32 (SEE: 25; IA: 07)

Preliminaries: Review of earlier related concepts-Groups and their simple properties. (3)

Class equations on groups and related theories: Conjugacy class equations, Cauchy’s theorem, p-Groups, Sylow theorems and their applications, simple groups. (6)

Direct Product on groups: Definitions, discussion on detailed theories with applications. (6)

Solvable groups: Related definitions and characterization theorems, examples. (6)

Group action: Definition and relevant theories with applications. (4)

The Head of the Department of Mathematics

Contd..
References:
1. I. N. Herstein – Topics in Algebra.
4. S. Lang – Algebra.
5. J. B. Fraleigh – A First Course in Abstract Algebra.

Operations Research–I
(Pure and Applied Streams)
Marks: 32 (SEE: 25; IA: 07)

Extension of Linear Programming Methods: Theory of Revised Simplex Method and algorithmic solution approaches to linear programs, Dual-Simplex Method, Decomposition principle and its use to linear programs for decentralized planning problems. (8)

Integer Programming (IP): The concept of cutting plane for linear integer programs, Gomory’s cutting plane method, Gomory’s All-Integer Programming Method, Branch-and-Bound Algorithm for general integer programs. (6)

Sequencing Models: The mathematical aspects of Job sequencing and processing problems, Processing n jobs through Two machines, processing n jobs through m machines. (5)

Nonlinear Programming (NLP): Convex analysis, Necessary and Sufficient optimality conditions, Cauchy’s Steepest descent method, Karush-Kuhn-Tucker (KKT) theory of NLP, Wolfe’s and Beale’s approaches to Quadratic Programs. (6)

References:
1. Linear Programming – G. Hadley.

* MATC 1.1 – MATC 1.3 are common to both the pure and applied streams

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**APPLIED STREAM**

**MATA 1.4**

**Mechanics of Solids**

*(Applied Stream)*

**Marks : 50 (SEE: 40; IA: 10)*

Brief discussion of tensor transformation, symmetric tensor, alternating tensor. Analysis of strain, Normal strain, shearing strain and their geometrical interpretations. Strain quadratic of Cauchy, Principal strains, Invariants, Saint-Venant’s equations of compatibility, equivalence of Eulerian and Lagrangian components of strain in infinitesimal deformation. (9)

Analysis of stress, stress tensor, Equations of equilibrium and motion. Stress quadric of Cauchy. Principal stress and invariants, strain energy function. (7)


Equilibrium of isotropic elastic solid: Deformations under uniform pressure. Deformations of prismatical bar stretched by its own weight and a cylinder immersed in a fluid, twisting of circular bar by couples at the ends. (4)

Torsion: Torsion of cylindrical bars, Torsional rigidity, Torsion function, Lines of shearing stress, simple problems related to circle, ellipse and equilateral triangle. (4)

Waves: Propagation of waves in an isotropic elastic medium, waves of dilatation and distortion. Plane waves.

References:

Nonlinear Dynamics

(Applyed Stream)

Marks: 50 (SEE: 40; IA: 10)

Linear autonomous systems: Linear autonomous systems, existence, uniqueness and continuity of solutions, diagonalization of linear systems, fundamental theorem of linear systems, the phase paths of linear autonomous plane systems, complex eigen values, multiple eigen values, similarity of matrices and Jordon canonical form, stability theorem, reduction of higher order ODE systems to first order ODE systems, linear systems with periodic coefficients.

Linearization of dynamical systems: Two, three and higher dimension. Population growth. Lotka-Volterra system.


References:

PURE STREAM

MATP 1.4
Differential Geometry – I
(Pure Stream)
Marks: 50 (SEE: 40; IA: 10)

Vector valued functions, Directional Derivatives, Total derivatives, Statement of Inverse and Implicit Function Theorems, Curvilinear coordinate system in E3. Reciprocal base system. Riemannian space. Reciprocal metric tensor, Christoffel symbols, Covariant differentiation of vectors and tensors of rank 1 and 2. (8)

Riemannian curvature tensor, Rieci tensor and scalar curvature. Space of constant curvature, Einstein space. On the meaning of covariant derivative. Intrinsic differentiation. Parallel vector field. (10)


Regular curves, curvature, torsion, curves in plane, signed curvature, curves in spaces, Serret Frenet formulae, Isoperimetric inequality, four vertex theorem. (7)
Introduction to surface, Definition example, first fundamental form of surfaces. (7)

References:
2. L. P. Eisenhart : An Introduction to Differential Geometry (with the use of Tensor Calculus).

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Contd..
5. U. C. De, Absos Ali Shaikh and Joydeep Sengupta: Tensor Calculus.
9. Differential Geometry of curves and surfaces, M. P Do Carmo
10. Calculus on Manifolds, M. Spivak

Topology–1
(Pure Stream)
Marks: 50 (SEE: 40; IA: 10)

Definition and examples of topological spaces. Basis for a given topology, necessary and sufficient condition for two bases to be equivalent, sub-base, topologizing of two sets from a sub base. Closed sets, closure and interior, their basic properties and their relations. Neighbourhoods, exterior and boundary, dense sets. Accumulation points and derived sets. Subspace topology.

Continuous, open, closed mappings, examples and counter examples, their different characterizations and basic properties, Pasting lemma, homeomorphism, topological properties.

The countability axioms, Separation axioms, Urysohn’S lemma and Tietzes extension theorem (Statements only) and some of their applications.

References:
1. M. A. Armstrong, Basic Topology, Springer (India), 2004,
2. J.R. Munkres, Topology, 2nd Ed., PHI (India), 2002,
3. J. M. Lee: Introduction to topological Manifolds,

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Contd..
II. The Second Semester

MATCB 2.1
Choice Based Paper
(Pure and Applied Streams)
Marks : 100

History of Mathematics. Objectives, Babylonian and Egyptian mathematics, Greek mathematics, Pythagoras, Euclid and the elements of geometry, Archimedes, Apollonius, Development of Trigonometry, Development of Algebra, Development of Analytic Geometry, Development of Calculus, Development of Selected Topics of Modern Mathematics, Modern geometries, Modern algebra, Methods of real analysis. (20)


Transportation and assignment problems. (4)

Components of a network. Shortest Path Method: Dijkstra’s Algorithm, Floyd’s Algorithm. A brief introduction to PERT and CPM, Components of PERT/CPM Network and precedence relationships, Critical path analysis. (6)

Linear Algebra. Matrix: definition, order, symmetric and skew symmetric matrices, determinant of a matrix, elementary properties of determinants, inverse of a matrix, normal form of a matrix, rank of a matrix, elementary concept of a vector space, linear dependence and independence of vectors, basis of a vector space, row space, column space, solution of system of linear equations, Cramar’s rule, Eigen values and Eigen vectors of matrices, Cayley Hamilton Theorem, Diagonalization of matrices. (20)

Dynamical Systems.
Linearization of dynamical systems: Two, three and higher dimension. Population growth. Lotka-Volterra system. (5)


References:

8. H.A. Taha, Operations Research
9. J.G. Chakraborty and P.R. Ghosh. Linear Programming and Game Theory
11. I.N. Herstein: Topics in Algebra.

MATCB 2.1 is based on the choices of the students of Other Department(s)
MATC 2.2
Real Analysis–II
(Pure and Applied Streams)
Marks: 32 (SEE: 25; IA: 07)

The Lebesgue measure: Definition of the Lebesgue outer measure on the power set of R, countable subadditivity, Carathéodory’s definition of the Lebesgue measure and basic properties. Measurability of an interval (finite or infinite), Countable additivity, Characterizations of measurable sets by open sets, \( G_\alpha \) sets, closed sets and \( F_\sigma \) sets. Measurability of Borel sets, Existence of non-measurable sets  

\( 8 \)

Measurable functions: Definition on a measurable set in R and basic properties, Simple functions, Sequences of measurable functions, Measurable functions as the limits of sequences of simple functions, Lusin’s theorem on restricted continuity of measurable functions, Egoroff’s theorem, Convergence in measure

\( 5 \)

The Lebesgue integral: Integrals of non-negative simple functions, The integral of non-negative measurable functions on arbitrary measurable sets in R using integrals of non-negative simple functions, Monotone convergence theorem and Fatou’s lemma, The integral of Measurable functions and basic properties, Absolute character of the integral, Dominated convergence theorem, Inclusion of the Riemann integral, Riesz-Fischer theorem on the completeness of the space of Lebesgue integrable functions.

\( 8 \)

Lebesgue integrability of the derivative of a function of bounded variation on an interval. Descriptive characterization of the Lebesgue integral on intervals by absolutely continuous functions.

\( 4 \)

References:
3. H. L. Royden: Real Analysis.
5. A. G. Das: The Generalized Riemann Integral.
7. W. Siepinsky: Cardinal Number and ordinal Number.
Complex Analysis – II
(Pure and Applied Streams)
Marks : 32 (SEE: 25; IA: 07)


(15)


(7)

Multivalued functions – branch point. Idea of winding number.

(3)

References :
5. J. B. Conway : Functions of One Complex Variable.

Functional Analysis – II
(Pure and Applied Streams)
Marks : 36 (SEE: 30; IA: 06)

Linear operators, Linear operators on normed linear spaces, continuity, bounded linear operators, norm
of an operator, various expressions for the norm. Spaces of bounded linear operators. Inverse of an
operator.

(8)

Linear functionals. Hahn-Banach theorem (without proof), simple applications. Normed conjugate
space and separability of the space. Uniform boundedness principle, simple application.

(5)

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Contd..
Inner product spaces, Cauchy Schwarz’s inequality, the induced norm, polarization identity, parallelogram law.

Orthogonality, Pythagoras Theorem, orthonormality, Bessel’s inequality and its generalisation.

Hilbert spaces, orthogonal complement, projection theorem. The Riesz’s representation theorem. Convergence of series corresponding to orthogonal sequence, Fourier coefficient, Perseval’s identity.

References:

MATC 2.1
Mechanics – II (Classical Mechanics)
(Pure and Applied Streams)
Marks: 32 (SEE: 25; IA: 07)


Canonical Transformations: Canonical coordinates and canonical transformations. Poincaré theorem. Lagrange’s and Poisson’s brackets and their variance under canonical transformations, Hamilton’s equations of motion in Poisson’s bracket. Jacobi’s identity. Hamilton-Jacobi equation. (4)


References:
2. Greenwood: Dynamics.
3. F. Chorlton: Dynamics.
4. Routh: Dynamics.
5. H. Lamb: Dynamics.

Abstract Algebra – II
(Pure and Applied Streams)
Marks: 32 (SEE: 25; IA: 07)

Preliminaries: Review of earlier related concepts-Rings, integral domains, fields and their simple properties. (3)

Detailed discussion on rings: Classification of rings, their definitions and characterization theorem with examples and counter examples. Polynomial rings, division algorithm, irreducible polynomials, Eisenstein’s criterion for irreducibility. (6)

Ideals in rings: Definitions, classifications with related theorems, examples and counter examples. (6)

Domains in rings: Classification, definitions and related theories with example and counter examples. (6)

Field extensions: Definition and simple properties. (4)

References:
1. I. N. Herstein – Topics in Algebra.

(S. Pal)
The Head of the Department of Mathematics

Contd..
4. S. Lang – Algebra.
5. J. B. Fraleigh – A First Course in Abstract Algebra.
10. Luthar and Passi – Algebra (Vol. 1).

**Operations Research – II**  
(Pure and Applied Streams)  
Marks : 36 (SEE: 30; IA: 6)

**Sensitivity Analysis** : Changes in price vector of objective function, changes in resource requirement vector, addition of decision variable, addition of a constraint. (6)

**Parametric Programming** : Variation in price vector, Variation in requirement vector. (4)

**Replacement and Maintenance Models** : Failure mechanism of items, General replacement policies for gradual failure of items with constant money value and change of money value at a constant rate over the time period, Selection of best item (6)

**Dynamic Programming (DP)** : Basic features of DP problems, Bellman’s principle of optimality, Multistage decision process with Forward and Backward recursive relations, DP approach to stage-coach problems. (5)

**Non-Linear Programming (NLP)** : Lagrange Function and Multipliers, Lagrange Multipliers methods for nonlinear programs with equality and inequality constraints. (4)

Separable programming, Piecewise linear approximation solution approach, Linear fractional programming. (5)

**References** :
1. Linear Programming – G. Hadley.

* MATC 2.2 AND MATC 2.3 are common to both the pure and applied streams

**APPLIED STREAM**

**MATA 2.4**

Mechanics of Fluids
(Applied Stream)

**Marks : 60 (SEE: 50; IA: 10)**


**Equations of Motion** : Lagrange’s and Euler’s equations of motion. Bernoulli’s theorem. Cauchy’s integrals. Impulsive action. (8)

**Motion in Two Dimensions** : Stream function. Sources, sinks and doublets. Images. Image of a source (sink) with regard to a plane and a sphere. Image of a doublet with regard to a sphere. Images in two dimensions. Milne-Thomson circle theorem. Blasius theorem. (8)


**Vortex Motion** : Vortex motion and its simple properties. Motion due to circular and rectilinear vortices. Vortex pair and doublet. Karman vortex street. (8)

**Viscous Liquid Motion** : Stress components in real fluid. Rate of strain quadric. Stress analysis in fluid motion. Relation between stress and rate of strain. Navier-Stokes’ equations. Plane Poiseuille and Couette flow between two parallel plates. Flow through tubes of uniform cross-sections in the form of circle, annulus, ellipse under constant pressure gradient. (8)

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The Head of the Department of Mathematics

Contd..
References:
3. F. Chorlton: Text Book of Fluid Dynamics.

Stochastic Processes
(Applied Stream)
Marks: 40 (SEE: 30; IA: 10)

Review of Probability: Random variables, conditional probability and independence, bivariate and
multi-variate distributions, probability generating functions, characteristic functions, convergence
concepts. (10)

Conditional Expectation: Conditioning on an event, conditioning on a discrete random variable,
conditioning on an arbitrary random variable, conditioning on a sigma-field. (5)

The Random Walk: unrestricted random walk, types of stochastic processes, gambler’s ruin problem,
generalisation of the random walk model. (5)

Markov Chains: Definitions, Chapman-Kolmogorov equation, Equilibrium distributions, Classification
of states, Long-time behaviour. Stationary distribution. Branching process. (5)

Stochastic process in continuous time: Poisson process and Brownian motion. (5)

References:
5. Introduction to Stochastic Processes: Hoel, Port, Stone

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Contd..
PURE STREAM

MATP 2.4

Differential Geometry–II

(Pure Stream)

Marks : 50 (SEE: 40; IA: 10)

Curves in the plane and space, surfaces in three-dimension, Smooth surface, Tangents and derivatives, normal and orientability, Examples of surfaces. (10)

The first fundamental form, Length of curves on surfaces, Isometries of surfaces, Conformal mapping of surfaces, (10)

Curvature of surfaces, The second fundamental form, The Gauss and Weingarten map, Normal and geodesic curvatures, Parallel transport and covariant derivative. (10)

Gaussian, mean and principal curvatures, Gauss Theorema Egregium, Minimal surface, The Gauss Bonnet Theorem. Abstract differentiable manifolds and examples, Tangent Spaces (10)

References :

3. L. P. Eisenhart : An Introduction to Differential Geometry (with the use of Tensor Calculus).
5. U. C. De : Differential Geometry of Curves and Surfaces in E³ (Tensor Approach).
6. Riemannian Geometry, M. P. Do Carmo

Topology–II

(Pure Stream)

Marks : 50 (SEE: 40; IA: 10)

Connectedness : Examples, various characterizations and basic properties. Connectedness on the real line. Components and quasi components. Path connectedness and path components. (10)

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Contd..
Compactness : Characterizations and basic properties of compactness, Lebesgue, lemma. Sequential compactness, BW Compactness and countable compactness. Local compactness and Baire Category Theorem. (10)

Identification spaces: Constructing a Mobius strip, identification topology, Orbit spaces. (8)

Some Matrix Lie Groups : Some elementary properties of topological groups, $GL(n, R)$ as a topological group and its subgroups. (10)

Fundamental groups, calculation of fundamental group of $S^1$. (2)

References:

1. M. A. Armstrong, Basic Topology, Springer (India), 2004,
2. J.R. Munkres, Topology, 2nd Ed., PHI (India), 2002,
3. J. M. Lee : Introduction to topological Manifolds,
III. The Third Semester

**MATC 3.1**

**Linear Algebra**

*(Pure and Applied Streams)*

**Marks : 40 (SEE: 30; IA: 10)*

**Matrices over a field:** Matric polynomial, characteristic polynomial, eigen values and eigen vectors, minimal polynomial. *(6)*

**Linear Transformation (L.T.):** Definition and the algebra of L.T., Rank and Nullity of L.T., Dual space, dual basis, Representation of L.T. by matrices, Change of basis. *(8)*

**Normal forms of matrices:** Diagonalization of matrices, Smith's normal form, Invariant factors and elementary divisors, Jordan canonical form, Rational (or Natural Normal) form, triangular forms, *(10)*

**Bilinear and Quadratic forms:** Bilinear forms, quadratic forms, reduction and classification of quadratic forms. *(6)*

**References :**

1. I. N. Herstein: Topics in Algebra.
3. B.C. Chatterjee: Linear Algebra.

**Special Functions**

*(Pure and Applied Streams)*

**Marks : 25 (SEE: 20; IA: 05)*

Solutions of Hypergeometric, Bessel, Legendre, Hermite differential equations. *(4)*

Legendre polynomial: Generating relation, Recurrence relations, Rodrigue’s formula, Schlafli’s and Laplace’s integral formulae, Orthogonal property, Reconstruction of the Legendre differential equations. *(4)*

Hermite and Laguerre polynomials: Generating relations, Recurrence relations, Rodrigue’s formulae, Orthogonal properties, Reconstructions of the respective differential equations. *(6)*

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Contd..
Chebyshev polynomial: Definition, Series representation, Recurrence relations, Deduction of Chebyshev differential equation, Orthogonal property.

Bessel’s functions: Generating relation for integral index, Recurrence relations, Representations for the indices $\frac{1}{2}$ and $-\frac{1}{2}$, Bessel’s integral Formulae, Bessel’s function of second kind.

References:
2. N. N. Lebedev: Special Functions and their Applications.
3. I. N. Sneddon: Special Functions of Mathematical Physics and Chemistry.

**Integral Equations & Integral Transforms**
(Pure and Applied Streams)

**Marks**: 35 (SEE: 30; IA: 05)


   Hilbert-Schmidt theory: Symmetric kernels, Orthogonal system of functions, Fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, Hilbert-Schmidt theorem.


Applications: Applications of integral transforms to solve two-dimensional Laplace and one-dimensional diffusion and wave equations.

References:
1. S. G. Michelins: Linear Integral Equations.
3. R. P. Kanwal: Linear Integral Equations
8. I. N. Sneddon: The Use of Integral Transforms.

*MATC 3.1 is common to both the pure and applied stream

APPLIED STREAM

MATA 3.2
Fuzzy Set Theory
(Pure and Applied Streams)

Marks: 26 (SEE: 20; IA: 06)

Interval Arithmetic: Interval numbers, arithmetic operations on interval numbers, distance between intervals, two level interval numbers.

Basic concepts of fuzzy sets: Types of fuzzy sets, \( \alpha \)-cuts and its properties, representations of fuzzy sets, decomposition theorems, support, convexity, normality, cardinality, standard set-theoretic operations on fuzzy sets, Zadeh’s extension principle.

Fuzzy Relations: Crisp versus fuzzy relations, fuzzy matrices and fuzzy graphs, composition of fuzzy relations, relational join, binary fuzzy relations.

Fuzzy Arithmetic: Fuzzy numbers, arithmetic operations on fuzzy numbers (multiplication and division on \( \mathbb{R}^+ \) only), fuzzy equations.
References:

**Computer Programming in ‘C’ (Theory)**

*(Pure and Applied Streams)*

**Marks : 37 (SEE: 30; IA: 07)*

Introduction and a Brief History of ‘C’ Language.  

**Fundamentals of ‘C’ Language**: Basic structure of a ‘C’ program, Basic Data type, Constants and Variables, Identifier, Keywords, Constants, Basic data type, Variables, Declaration and Initialization, Statements and Symbolic constants. Compilation and Execution of a ‘C’ program.

**Operators and Expressions**: Arithmetic, Relational, Logical operators. Increment, Decrement, Control, Assignment, Bitwise, and Special operators. Precedence rules of operators, Type Conversion (casting), Modes of arithmetic expressions, Conditional expressions.

**Input / Output Operations**: Formatted I/O - Single character I/O (getchar(), putchar()), Data I/O (scanf(), printf()), String I/O (gets(), puts()). Programming problems.

**Decision Making Statements**: Branching – *if* Statement, *if ...else* Statement, Nested *if .... else* Statement. *else ......if* and *switch* Statements.


**Functions**: Function declaration, Library functions, User defined function, Passing argument to a function, Recursion. Programming problems.

**Arrays**: Array declaration and static memory allocation. One dimensional, two dimensional and multidimensional arrays. Passing arrays to functions. Sparse matrix.

**Pointers**: Basic concepts of pointer, Functions and Pointers. Pointers and Arrays, Memory allocation, Passing arrays to functions, Pointer type casting. Programming problems.

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Contd..

File Operations: File Input/Output operations – Opening and Closing a file, Reading and Writing a file. Character counting, Tab space counting, File-Copy program, Text and Binary files. (4)

References:
2. Let Us C: Y. Kanetkar.
5. The C Programming Language: B.W. Kernighan and D. Ritchie.

Numerical Analysis (Practical)
(Applied Streams)
Marks: 37 (SEE: 30; IA: 07)
(*Laboratory Note Book: 5 marks + Viva-Voce: 7 marks + Compilation and Execution of Two Problems).

Numerical Computation
(i) Interpolation and Approximation:
   a) cubic spline interpolation,
   b) Least square approximation.
(ii) Numerical Integration: (a) Gaussian quadrature, (b) Romberg formula.
(iii) Eigen value and Eigenvector Problems: Power method.
(iv) Solutions of Non-linear Equations: Newton-Raphson method.

Practical Examination Related Criteria:
(i) Laboratory Clearance be taken by the students prior to commencement of Practical Examination.
(ii) The Lab. Assignment Dissertations of the students be submitted prior to commencement of Practical Examination.

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Contd..
(iii) Duration of Practical Examination will be 3 (Three) hours.
(iv) One External Examiner be appointed for Practical Examination.

References :
1. Balagurusamy, E. – Programming in ANSI C
2. Y. Kanetkar – Let Us C
3. B. S. Gottfred – Programming in C Language
4. C. K. Loudon – Mastering Algorithm in.
5. B.W. Kernighan and D. Ritchie – The C Programming Language
6. N. Kalicharan – C by Example

MATA 3.3
Dynamical Systems
(Applied Stream)
Marks : 50 (SEE: 40; IA: 10)

Autonomous and non-autonomous systems : Orbit of a map, fixed point, equilibrium point, periodic point, circular map, configuration space and phase space. (8)

Nonlinear oscillators-conservative system. Hamiltonian system. Various types of oscillators in nonlinear system viz. simple pendulum, and rotating pendulum. (5)

Limit cycles : Poincaré-Bendixon theorem (statement only). Criterion for the existence of limit cycle for Liénard’s equation. (4)


Randomness of orbits of a dynamical system: The Lorentz equations, Chaos, Strange attractors. (3)

References:
5. K. Arrowsmith: Introduction to Dynamical Systems.

Numerical Analysis (Theory)
(Applied Stream)

Marks: 50 (SEE: 40; IA: 10)

Interpolation: Hermite’s interpolation. Interpolation by iteration – Aitken’s and Neville’s schemes. (5)

Approximation of Function: Least square approximation. Weighted least square approximation. Orthogonal polynomials, Gram–Schmidt orthogonalisation process, Chebysev polynomials, Mini-max polynomial approximation. (5)


Systems of Linear Algebraic Equations: Direct methods, Factorization method. (4)

Eigen value and Eigenvector Problems: Direct methods, Iterative method – Power method. (4)
Nonlinear Equations: Fixed point iteration method, convergence and error estimation. Modified Newton-Raphson method, Muller’s method, Inverse interpolation method, error estimations and convergence analysis. (6)


References:
**MATA 3.4**  
**Mathematical Biology**  
**(Applied Stream)**  
**Marks : 70 (SEE: 55; IA: 15)**

**Effect of Nutrients on autotrophy-herbivore interaction:** Introduction, Models on nutrient recycling and its stability, Effect of nutrients on autotrophy herbivore stability, Models on herbivore nutrient recycling on autotrophic production.  
(7)

**Dynamics of Phytoplankton-Zooplankton system:** Introduction, Models on phytoplankton-zooplankton system and its stability, Bio-control in plankton models with nutrient recycling.  
(7)

(7)

**Mathematical models in ecology:** Discrete and Continuous population models for single species. Logistic models and their stability analysis. Lag factor and stability of population steady states.  
(7)

(12)

**Continuous models for three or more interacting populations:** Food chain models. Stability of food chains. Species harvesting in competitive environment, Economic aspects of harvesting in predator-prey systems.  
(10)

**Interaction of Ratio-dependent models:** Introduction, May’s model, ratio-dependent models of two interacting species, two prey-one predator system with ratio-dependent predator influence- its stability and persistence.  
(5)

**References :**


**Electromagnetic Theory**

*(Applied Stream)*

**Marks : 30 (SEE: 25; IA: 05)*


**Steady currents**: Current vector, ohm’s law, Differential equations of the field and flow. (2)


**Maxwell’s equations**: Equations of continuity for time – varying fields, Maxwell equations. Boundary conditions. Maxwell’s stress. (3)


**Relativistic electrodynamics**: The principle of relativity. Lorentz transformation, Transformation of electrodynamics variables. Theory of special relativity (statement of the principles only). Transform relations for systems in relative motion, Derivation of electromagnetic relations. (4)

**References**:

1. Jackson, J, D – Classical Electrodynamics.
5. Sommerfield, A. – Electrodynamics

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The Head of the Department of Mathematics

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**PURE STREAM**

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**MATP 3.2**

Fuzzy Set Theory

(Pure and Applied Streams)

Marks: 26 (SEE: 20; IA: 06)

**Interval Arithmetic:** Interval numbers, arithmetic operations on interval numbers, distance between intervals, two level interval numbers. (2)

**Basic concepts of fuzzy sets:** Types of fuzzy sets, α-cuts and its properties, representations of fuzzy sets, decomposition theorems, support, convexity, normality, cardinality, standard set-theoretic operations on fuzzy sets, Zadeh’s extension principle. (8)

**Fuzzy Relations:** Crisp versus fuzzy relations, fuzzy matrices and fuzzy graphs, composition of fuzzy relations, relational join, binary fuzzy relations. (4)

**Fuzzy Arithmetic:** Fuzzy numbers, arithmetic operations on fuzzy numbers (multiplication and division on $\mathbb{R}^+$ only), fuzzy equations. (6)

**References:**

The Head of the Department of Mathematics

Computer Programming in ‘C’ (Theory)
(Pure and Applied Streams)
Marks : 37 (SEE: 30; IA: 07)

Introduction and a Brief History of ‘C’ Language.

Fundamentals of ‘C’ Language : Basic structure of a ‘C’ program, Basic Data type, Constants and Variables, Identifier, Keywords, Constants, Basic data type, Variables, Declaration and Initialization, Statements and Symbolic constants. Compilation and Execution of a ‘C’ program.

Operators and Expressions : Arithmetic, Relational, Logical operators. Increment, Decrement, Control, Assignment, Bitwise, and Special operators. Precedence rules of operators, Type Conversion (casting), Modes of arithmetic expressions, Conditional expressions.

Input / Output Operations : Formatted I/O - Single character I/O (getchar(), putchar()), Data I/O (scanf(), printf()), String I/O (gets(), puts()). Programming problems.

Decision Making Statements : Branching – if Statement, if ......else Statement, Nested if.... else Statement. else ......if and switch Statements.


Functions : Function declaration, Library functions, User defined function, Passing argument to a function, Recursion. Programming problems.

Arrays : Array declaration and static memory allocation. One dimensional, two dimensional and multidimensional arrays. Passing arrays to functions. Sparse matrix.

Pointers : Basic concepts of pointer, Functions and Pointers. Pointers and Arrays, Memory allocation, Passing arrays to functions, Pointer type casting. Programming problems.


File Operations : File Input / Output operations – Opening and Closing a file, Reading and Writing a file. Character counting, Tab space counting, File-Copy program, Text and Binary files.

References :
7. Let Us C : Y. Kanetkar.

**Computer Programming in ‘C’ (Practical)**

*(Pure Streams)*

**Marks**: 37 (SEE: 30; IA: 07)

(*Laboratory Note Book: 5 marks + Viva-Voce: 5 marks
 + Compilation and Execution of Two Problems**: 20 marks).

1. **Basic Computation**:
   (i) Summation of natural numbers up to a given number.
   (ii) Summation of odd / even numbers up to a given number.
   (iii) Evaluation of the factorial of a given number.
   (iv) Summation of all the digits of a number.
   (v) Determination of the mean, variance and standard deviation from a list of numbers. *(6)*

2. **Number Testing [Hints are provided]**:
   (i) Generation of all the terms of Fibonacci Series up to a certain number.
      (Hints: General term in Fibonacci Series is as follows:
      \[ F[i] = i, \text{ if } i < 2 \]
      \[ = F[i - 1] + F[i - 2], \text{ if } i \geq 2 \]
      (The resultant series is: 0,1,1,2,3,5,8,13,21,34,55 etc.)
   (ii) Testing of whether a number is prime or not.
   (iii) Checking whether a number is Armstrong number or not (Hints: A number is Armstrong if sum of the cubes of it digits, matches with the number – e.g., 153=1^3 + 5^3 + 3^3).
   (iv) Checking whether a number is Peterson number or not (Hints: A number is Peterson if sum of the factorials of it digits, matches with the number – e.g., 145=1! + 4! + 5!).
   (v) Checking whether a number is Perfect number or not (Hints: a number is Perfect if sum of the factors (except itself), matches with the number- e.g. 28=1+2+4+7+14). *(8)*

3. **Series Computation**:
   (i) The Exponential Series: \( e^x \) (\( = 1 + x + x^2/2! + x^3/3! \ldots \)up to n terms).
   (ii) The base of a Natural Log: \( e \) (\( = 1 + 1/1! + 1/2! + 1/3! \ldots \up to n terms).)
   (iii) The Sine Series: sin\( (x) = x - x^3/3! + x^5/5! - x^7/7!+ \ldots \)up to n terms).
   (iv) The roots of a quadratic equation: \( ax^2+bx +c =0 \) for any input a ,b, c. *(8)*

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Contd..
4. Matrix Operation:
   (i) Matrix Addition and Matrix Multiplication using 2D Array.
   (ii) Matrix Inversion using 2D Array.
   (iii) Sorting of a list of numbers.
   (iv) Finding of the Amplitude, Modulus, Addition and Subtraction of Complex numbers using Structure.

**Applications of Branches, Loops, Arrays and Structures mainly be taken into account in Lab. Assignment.**

Practical Examination Related Criteria:

(i) Laboratory clearance be taken by the students prior to commencement of Practical Examination.
(ii) The Lab. Assignment Dissertations of the students be submitted prior to commencement of Practical Examination.
(iii) Duration of practical examination will be 3 (Three) hours.
(iv) One External Examiner be appointed for Practical Examination.

References:

2. Let Us C : Y. Kanetkar.
5. The C Programming Language : B.W. Kernighan and D. Ritchie.
6. C by Example : N. Kalicharan.

MATP 3.3
Topological Groups
(Pure Stream)
Marks : 50 (SEE: 40; IA: 10)
Definition of topological group and examples. Right and left translations. Homogeneity property in a topological group. Fundamental neighbourhood system of the identity element. Separation axioms in topological groups.

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Contd..

Uniform structure of a topological group. Locally compact topological group and its basic properties. Properties of topological groups involving connectedness. Invariant pseudo-metrics. Character groups.

References:
1. T. Husain: Introduction to Topological Groups.
5. F. J. Higgins: An Introduction to Topological Groups.

Measure Theory
(Pure Stream)
Marks: 50 (SEE: 40; IA: 10)

Measures: Class of Sets, Measures, The extension Theorems and Lebesgue-Stieljes measures, Caratheodory extension of measure, Completeness of measure

Integrations: Measurable transformations, Induced measures, distribution functions, Integration, More on Convergency, Product of two measure spaces. Fubini’s theorem.


Differentiations: The Lebesgue-Radon-Nikodym theorem, Signed measures, Product Measures

References:
1. Measure Theory: K. B. Athreya and S. Lahiri,
2. Introduction to Probability and Measure: Parthasarathi,
3. Real analysis, Modern Techniques and their applications: G. B. Folland,
4. Measure Theory: P. R. Halmos

Contd..
MATP 3.4
Calculus of $\mathbb{R}^n$
(Pure Stream)
Marks : 50 (SEE: 40; IA: 10)

Differentiation on $\mathbb{R}^n$: Directional derivatives and continuity, the total derivative and continuity, total derivative in terms of partial derivatives, the matrix transformation of $T : \mathbb{R}^n \to \mathbb{R}^n$. The Jacobian matrix.

The chain rule and its matrix form. Mean value theorem for vector valued function. Mean value inequality.

A sufficient condition for differentiability. A sufficient condition for mixed partial derivatives.

Functions with non-zero Jacobian determinant, the inverse function theorem, the implicit function theorem as an application of Inverse function theorem. Extremum problems with side conditions – Lagrange’s necessary conditions as an application of Inverse function theorem.

Integration on $\mathbb{R}^n$: Integral of $f : A \to \mathbb{R}$ when $A \subset \mathbb{R}^n$ is a closed rectangle. Conditions of integrability. Integrals of $f : C \to \mathbb{R}$, $C \subset \mathbb{R}^n$ is not a rectangle, concept of Jordan measurability of a set in $\mathbb{R}^n$.

Fubini’s theorem for integral of $f : A \times B \to \mathbb{R}$, $A \subset \mathbb{R}^n$, $B \subset \mathbb{R}^n$, are closed rectangles.

Fubini’s theorem for $f : C \to \mathbb{R}$, $C \subset A \times B$.

Formula for change of variables in an integral in $\mathbb{R}^n$.

References:
1. T. M. Apostol : Mathematical Analysis.

Operator Theory
(Pure Stream)
Marks : 50 (SEE: 40; IA: 10)

Conjugate (or dual) spaces, determination of conjugate spaces of $\mathbb{R}^n$, $\ell_p^\ell_p$ for $1 \leq p < \infty$. Representation theorem for bounded linear functionals on $C[a, b]$ (Statement only), Conjugate spaces of $C[a, b]$ and some other spaces (results only).

References:
1. T. M. Apostol : Mathematical Analysis.

(S. Pal)
The Head of the Department of Mathematics

Contd..
Weak convergence and weak* convergence, characterization of weak convergence, sufficient condition for the equivalence of weak* convergence and weak convergence in the dual space. (6)

Canonical imbedding, reflexive spaces, connection between reflexivity and separability, embedding of n. ℓ. spaces into a Banach space, some consequences of reflexivity. (6)

Bounded linear operator, uniqueness theorem, adjoint of an operator and some properties. (3)

Self adjoint, compact, normal, unitary, projection, positive operators, square roots of positive operators: Characterizations and some of their basic properties. Conditions under which the sum of projections is also a projection, expression of the norm of self adjoint operator, invariant subspaces. Closed linear transformation, closed graph theorem and open mapping theorem. (15)

References:

8. A. E. Taylor: Introduction to Functional Analysis

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Contd..
IV. The Fourth Semester

MATC 4.1
Discrete Mathematics
(Applied and Pure Streams)
Marks: 65 (SEE: 50; IA: 10)


Lattices: Lattices as partial ordered sets. Their properties. Lattices as algebraic system. Sublattices. Direct products and Homomorphism. Some special Lattices e.g. complete complemented and distributed lattices. (5)

Boolean Algebra: Basic Definitions, Duality, Basic theorems, Boolean algebra as lattices, Sum and Product of Boolean algebra Minimal Boolean Expressions, Prime implicants, Logic gates and circuits. Truth tables, Boolean functions. Applications of Boolean Algebra to Switching theory (using AND, OR & NOT gates). Karnaugh Map method. (12)

Combinatorics: Introduction, Basic counting principles, permutation and combination, pigeonhole principles, Recurrence relations and generating functions. (8)


Push Down Automation (PDA). Equivalence of PDAs and Context Free Languages (CFLs), Computable Functions. (10)

References:
5. J. E. Hopcroft and J. D. Ullman: Introduction to Automata Theory, Languages and Computation.

(S. Pal)
The Head of the Department of Mathematics
Contd..
7. F. Harary: Graph Theory.
9. N. Deo: Graph Theory with Applications to Engineering and Computer Science.

Probability and Statistical Methods
( Applied and Pure Streams)
Marks: 40 (SEE: 30; IA: 10)


Definition and classification of stochastic processes. Markov chains with finite and countable state space, classification of states, limiting behaviour of \( n \)-step transition probabilities, stationary distribution.


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Contd..
Multivariate normal distribution, Hotelling’s T-square and Wishart distribution (without derivation) and their properties. Distribution of quadratic forms. Dimension reduction techniques: Principal component analysis, Discriminant analysis, Canonical correlation.

Life-testing models, reliability and hazard function, reliability of series and parallel systems.

References:


(S. Pal)
The Head of the Department of Mathematics

Contd..
Detailed Syllabi for the Optional Subjects with Covering of MATO 4.2 and MATO 4.3:

Optional Subjects for both Applied and Pure Streams

Optional Subject
Advanced Operations Research–I
(Applied and Pure Streams)
Marks: 100 (SEE: 80; IA -20)

Network Analysis – Network definitions, Minimal Spanning Tree Algorithm, Shortest Route Algorithms, Max-flow Min-cut theorem, Generalized Max-flow Min-cut theorem, linear programming interpretation of Max-flow Min-cut theorem, minimum cost flows. A brief introduction to PERT and CPM, Components of PERT/CPM Network and precedence relationships, Critical path analysis, PERT analysis in controlling project. (20)

Queueing Theory: Basic features of Queueing Systems, Operating characteristics of a Queueing System, Arrival and Departure (birth and death) distributions, Inter-arrival and service times distributions, Transient steady-state conditions in queuing process.
Poisson queueing models: (M / M / 1) : (∞ / FIFO / ∞) ; (M / M / 1) : (N / FIFO / ∞) ; (M / M / C) : (∞ / FIFO / ∞) ; (M / M / C) : (N / FIFO / ∞), C ≤ N ; (M / M / R) : (K / GD / K), R < K – machine servicing model; (12)

Simulation: A brief introduction to simulation, Advantages of simulations over traditional search methods, Limitations of simulation techniques, Computational aspects of simulating a system, random number generation in stochastic simulation, Monte-Carlo simulation and modelling aspects of a system, Simulation approaches to inventory and queueing systems. (6)

Linear Multi-Objective Programming (LMOP): Conversion of LMOP to linear programming, Minsum and Priority based Goal Programming (GP) approaches to LMOP problems, Fuzzy Set-Theoretic approaches to GP Problems. (6)

Hierarchical Decision Analysis: Introduction to Bilevel Programming (BLP) and Multilevel Programming (MLP), Fuzzy Programming approaches to BLP problems. (6)

Genetic Algorithms (GAs): Introduction to GAs, Robustness of GAs over traditional search methods. Binary encodings of candidate solutions, Schema Theorem and Building Block Hypothesis, Genetic

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Contd..
operators – crossover and mutation, parameters for GAs, Reproduction mechanism for producing Offspring, Darwinian Principle in evaluating objective function, Simple GA schemes, GA approaches to optimization problems.

Reference:
8. Inventory Control – J. Jonson and D. Montogomer.
11. Introduction to Theory of Queues – L. Takacs.
15. Linear Multiobjective Programming – M. Zeleny.

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Contd..
Optional Subject
Advanced Operations Research–II
(Applied and Pure Streams)
Marks : 100 (SEE: 80; IA -20)

Theory of Inventory Control : A brief introduction to Inventory Control, Single-item deterministic models without shortages and with shortages, models with price breaks. Dynamic Demand Inventory Models. (8)

Single-item stochastic models without Set-up cost and with Set-up cost (5)

Multi-item inventory models with the limitations on warehouse capacity, Average inventory capacity, Capital investment. (4)

Information Theory : Information concept, expected information, bivariate information theory, economic relations involving conditional probabilities, Entropy and properties of entropy function. (12)

Coding theory : Communication system, encoding and decoding, Shannon-Fano encoding procedure, Haffman encoding, noiseless coding theory, noisy coding, error detection and correction, minimum distance decoding, family of codes, Hammining code, Golay code, BCH codes, Reed-Muller code, perfect code, codes and design, Linear codes and their dual, weight distribution. (12)

Markovian Decision Process : Ergodic matrices, regular matrices, imbedded Markov Chain method for Steady State solution. (8)

Reliability : Elements of Reliability theory, failure rate, extreme value distribution, analysis of stochastically falling equipments including the reliability function, reliability and growth model. (8)

Geometric Programming (GP):
Posynomial, Signomial, Degree of difficulty, Unconstrained minimization problems, Solution using Differential Calculus, Solution seeking Arithmetic-Geometric inequality, Primal dual relationship & sufficiency conditions in the unconstrained case, Constrained minimization, Solution of a constrained Geometric Programming problem, Geometric programming with mixed inequality constrains, Complementary Geometric programming. (12)

References :
1. An Introduction to Information Theory – F. M. Reza.
3. Graph Theory with Applications to Engineering and Computer Science – N. Deo.
5. Coding and Information Theory – Steven Roman.
6. Coding Theory, A First Course – San Ling and Chaoping Xing.
7. Introduction to Coding Theory – J. H. Van Lint
8. The Theory of Error Correcting Codes – Mac William and Sloane.

Optional Subject

Fuzzy Sets and Systems

(Appplied and Pure Streams)

Marks: 100 (SEE: 80; IA: 20)

**Fuzzy Sets:** From crisp sets to fuzzy sets: a shift of paradigm, preliminaries. (2)

**Operations on Fuzzy Sets:** Fuzzy complements, axioms of fuzzy complements, equilibrium, dual point, characterization theorem of fuzzy complements, increasing and decreasing generators. t-norms, t-conorms, their axioms and corresponding characterization theorems, dual triple. (10)

**Fuzzy Relations:** Fuzzy equivalence relations, fuzzy Compatibility relations, fuzzy ordering relations, Projections and cylindric extensions. (6)

**Fuzzy Arithmetic:** Linguistic variables, arithmetic operations on fuzzy numbers (On \(\mathbb{R}\), in general). (4)

**Defuzzification of Fuzzy Numbers:** Definition, Different types of defuzzification techniques. (5)

**Fuzzy Logic:** A brief review of Classical logic, fuzzy propositions, fuzzy quantifiers, fuzzy inference rules, inferences from fuzzy propositions. (12)

**Possibility Theory:** Fuzzy measures, evidence theory, belief measures and plausibility measures, possibility theory, necessity measures, possibility measures, possibility distributions, fuzzy sets and possibility theory, possibility theory versus probability theory. (8)

**Fuzzy Decision Making:** Introduction to decision-making in Fuzzy environment. Individual decision making, multiperson decision making, multicriteria decision making, fuzzy ranking methods, fuzzy linear programming, multiobjective fuzzy programming. (10)

**Fuzzy Control:** Expert Systems, Expert-Knowledge representation techniques, Input and Output variables, Fuzzy controller, Inference engine (rule-firing), Fuzzification. Mamdani fuzzy control System, Takagi-Sugeno fuzzy control System. (8)
References:
1. The Importance of Being Fuzzy – A. Sangalli.

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Contd..
Optional Subjects for Only Applied Stream

Optional Subject
Advanced Solid Mechanics
(Applied Stream)
Marks : 100 (SEE: 80; IA: 20)


Problems of semi-infinite solids with displacements or stresses prescribed on the plane boundary.


Radial and rotatory vibration of a solid and hollow sphere. Radial and torsional vibration of a circular cylinder.


Torsion of cylindrical bars of circular and oval sections. Bending of a prismatic bar of narrow rectangular cross-section by terminal couple. Spherical and cylindrical shell under internal pressure. Plastic deformation of flat rings.

Slip lines and plastic flow. Plastic mass pressed between two parallel planes.

References:

(S. Pal)
The Head of the Department of Mathematics

Contd..

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Optional Subject
Advanced Fluid Mechanics
(Appplied Stream)
Marks : 100 (SEE: 80; IA: 20)


Turbulent flow: Mean values. Reynolds theory. Mixing length theories. Momentum transfer theory. Taylor’s vorticity transfer theory. Karmann’s similarity hypothesis. Applications to the solutions of (i) mixing zone between two parallel flows, (ii) motion in a plane jet. Prandtl 1/7power law and its application to turbulent boundary layer over a flat- plate.

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(S. Pal)
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Contd..
References:

Optional Subject

Computational Fluid Mechanics
(Applied Stream)

Marks : 100 (SEE: 80; IA: 20)

A brief Introduction to Computational Fluid Mechanics.

Stationary convection: Diffusion equation (finite volume discretization schemes of positive type, upwind discretization).


Incompressible Navier-Stokes (NS) equations: Boundary conditions. Spatial and temporal discretization on collocated and on staggered grids.


Shallow water equations: One- and two-dimensional cases.

Scalar conservation laws: Godunov’s order Barrier Theorem. Linear Schemes.


**Unified methods**: computation of compressible and incompressible flow. \( (5) \)

**References:**

**Optional Subject**

**Magneto-Fluid Mechanics**

(Applied Stream)

**Marks**: 100 (SEE: 80; IA: 20)


**Incompressible magneto-hydrodynamic flow**: Parallel steady flow. One–dimensional steady viscous flow. Isentropic and homentropic flows. Hartmann and Couette flows. \( (12) \)

**Characteristics of MFD waves**: Characteristic equation. Characteristic determinant. Magneto hydrodynamic waves. Fast, slow, transverse and entropy waves. \( (15) \)

**MFD shock waves, and Jump relation**: The generalized Hugoniot condition. The compressive nature of magneto hydrodynamic shocks. Mach number, Subsonic and supersonic flows. Sub and super Alfvenic waves. \( (12) \)


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(S. Pal)
The Head of the Department of Mathematics

Contd..
References

Optional Subject
Plasma Physics
(Applied Stream)
Marks: 100 (SEE: 80; IA: 20)
Field of a moving point charge: Radiation from an accelerated charge. Radiation power. Damping force of radiation. Lagrangian and Hamiltonian for the motion of a charge particle in electromagnetic field. (10)

Non-relativistic motion: Non–relativistic motion of charged particles in electric and magnetic fields. Gradient and curvature drifts. (6)

Basic Plasma properties: Waves in unmagnetized and cold magnetized Plasmas. Radiation from plasma-the Bremsstratilung and Synchrotron radiation. Stream instabilities in cold plasma. (15)


Kinetic approach—Linearized Vlasov equations: Small amplitude Oscillations—Landau damping. (7)

Derivation of MHD equations: General properties, e.g. generalization of Bernoulli’s and Kelvin’s theorems, diamagnetic drifts and currents. Double-adiabatic theory for collisionless plasma—the Chew-Goldberger-low (CGL) equations. (7)

Dusty plasmas: Dusty plasmas and the role of dust in stellar environment, galactic and planetary systems.

References:

Optional Subject
Mathematics of Finance and Insurance
(Applied Stream)
Marks: 100 (SEE: 80; IA: 20)

Mathematics of Finance (SEE: 50; IA: 12)


Pricing by Arbitrage: A single –period option pricing model; Multi – period pricing model – Cox – Ross – Rubinstein model; Bounds on option prices. The Ito’s lemma and the Ito’s integral.

Dynamics of derivative prices: Stochastic differential equations (SDEs) –Major models of SDEs, Linear constant coefficient SDEs, Geometric SDEs, Square root process, Mean reverting process and Omstein- Uhlenbeck process.
Martingale measures and risk-neutral probabilities: Pricing of binomial options with equivalent martingale measures. (6)

The Black-Scholes option pricing: Model with no arbitrage approach, limiting case of binomial option pricing and risk–neutral probabilities. (6)


Mathematics of Insurance (SEE: 30; IA: 08):


Premium and ordering of risks: Premium calculation principles and ordering distributions. (5)


Time dependent risk models: Ruin problems and computations of ruin functions. Dual queuing models in continuous time and numerical evaluation of ruin functions. (6)

References:

Optional Subject
Seismology
(Applied Stream)
Marks: 100 (SEE: 80; IA: 20)


Bodily elastic waves: P wave (P-Wave) and Secondary wave (S-waves). The effect of gravity fluctuations. Effect of deviation from perfect elasticity. The Jeffereys–Lomnitz Law. (5)


Reflection and refraction of elastic waves: Laws of reflection and refraction. General equations for the two media. Case of incident Surface Horizontal (SH-wave), P-wave and Surface Vertical (SV-wave) incident against free plane boundary. Reflection and refraction of seismic waves. Lamb’s problem-line load suddenly applied on elastic half-space. Refraction of dispersed waves. (10)

Seismic rays in a spherically stratified earth model: The parameter p of a seismic ray. Relation between p, Δ, T for a given family of rays. Features of the relations between Δ and T corresponding to certain assigned types of variation with r. Derivation of the P-and S-velocity distributions from the (T, Δ) relations. Special velocity distributions, e.g. curvature of a seismic ray, rays in a homogeneous medium, circular rays. (10)

Amplitude of the surface motion due to seismic waves: Energy per unit area of wave front in an emerging wave. Relation between energy and amplitude Movements of the outer surface arising from an incident wave of given amplitude. Amplitude as a function of Δ. Loss of energy. (10)

Travel-time analysis: Parameters of earthquakes. Epicentral distance and azimuth of an observing station from an epicentre. Theory of the evolution of the main P travel-time table. (7)

Seismology and the earth’s upper layers and interior Positions: Theory of travel-times near earthquakes. Physical properties of earth’s upper layers. Discontinuities within the earth. (7)

References:
2. Richter, C. F.: Elementary Seismology

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The Head of the Department of Mathematics

Contd..

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Optional Subject

Computational Biology

(Applied Stream)

Marks: 100 (SEE: 80; IA: 20)

A brief review of computational aspects molecular biology.

**Basic concepts of molecular biology:** DNA and proteins. The central dogma. Gene and Genome sequences.

**Restriction maps:** Graphs. Interval graphs. Measuring fragment sizes.


**Sequence assembly:** Sequencing strategies. Assembly in practices, fragment overlap statistics, fragment alignment, sequence accuracy.

**Sequence comparisons methods:** Local and global alignment. Dynamic programming solution method. Multiple sequence alignment.

**Stochastic Approach to sequence alignment and sequence pattern-Hidden:** Markov chain method for biological sequences.

**References:**


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Contd..
Optional Subject
Mathematical Biology
(Applied Stream)

Marks : 100 (SEE: 80; IA: 20)

**Diffusion Model:** The general balance law, Fick’s law, diffusivity of motile bacteria. (5)

**Models for Developmental Pattern Formation:** Background, model formulation, spatially homogeneous and inhomogeneous solutions, Turing model, conditions for diffusive stability and instability, pattern generation with single species model. (10)

**Deterministic Epidemic Models:** Deterministic model of simple epidemic, Infection through vertical and horizontal transmission, General epidemic- Karmac-Mackendric Threshold Theorem, Recurrent epidemics, Seasonal variation in infection rate, allowance of incubation period. Simple model for the spatial spread of an epidemic. Proportional Mixing Rate in Epidemic: Introduction, SIS model with proportional mixing rate, SIRS model with proportional mixing rate. (10)

**Stochastic Epidemic Models:** Introduction, stochastic simple epidemic model, Yule-Furry model (pure birth process), expectation and variance of infective, calculation of expectation by using moment generating function. (5)

**Eco-Epidemiology:** Introduction, host-parasite-predator systems, viral infection on phytoplankton zooplankton (prey-predator) system. (5)

**Models for Population Genetics:** Introduction, basic model for inheritance of genetic characteristic, Hardy-Wienberg law, models for genetic improvement, selection and mutation- steady state solution and stability theory. (5)


**Models for other fluids:** Peristaltic motion in a channel and in a tube. Two dimensional flow in renal tubule. Lubrication of human joints. (5)

**References:**

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Optional Subject
Dynamical Oceanography
(Applied Stream)

Marks : 100 (SEE: 80; IA: 20)

Hydrothermic equations of seawater. Gibbs relation, Gibbs-Duhem relation, heat capacities, Vaisala frequency, Determination of the thermodynamic properties of seawater. (6)


Wave motions in the ocean. General properties of plane and nearly plane waves. Linearised small-amplitude waves under gravity in rotating stratified ocean-simple gyroscopic and internal waves, internal gravity waves, plane waves, the energetic of plane waves. Long wave equation for a continuously stratified fluid. Wave reflection and wave trapping by lateral boundaries. Nonlinear surface waves: the Stokes approximation, finite-amplitude wave in shallow water. The solitary wave. (18)

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Contd..
Turbulence: Basic concept. Time-averaged form of the momentum and continuity equations for incompressible flow. Eddy coefficients and their estimations. Elementary examples of the application of eddy coefficients. Salinity tongue in an ocean at rest. (10)


Tides and storm surges. Statistical theory of tides. Tidal harmonics channel theory of tides. (4)

References:
2. J. Pedlosky: Geophysical Fluid Dynamics.
4. O. M. Philips: Dynamics of the Upper Ocean.

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Optional Subject

Applied Functional Analysis

(Applied Stream)

Marks: 100 (SEE: 80; IA: 20)

Review of basic properties of Hilbert spaces. (5)


Optional control theory: Linear quadratic regulator problems with finite and infinite time intervals. Concept of hard constraints. Final value control. Time optimal control problems. (15)

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(S. Pal)
The Head of the Department of Mathematics

Contd..
References:
11. W. L. Bro gan: Modern Control Theory.
14. S. G. Tzafestas: Methods and Applications of Intelligent Control.

Optional Subject

Advanced Numerical Analysis (Theory and Practical)
(Applied Stream)
Marks: 100

Advanced Numerical Analysis: Theory (SEE: 50; IA: 12)

Interpolation: Newton’s bivariate interpolation, Triangular interpolation, Bilinear interpolation.
Approximation: Rational approximation, Continued fraction approximation, Pade approximation.
Solution of polynomial equation: Birge-Vieta method, Bairstaw method. (8)


Eigen value problems of real symmetric matrices: Bounds of Eigenvalues, Householder’s method, Given’s method, Inverse power method. (10)
Solution of nonlinear system of equations: Newton’s method, Steepest- Descent method, Convergence analysis.


References:

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Contd..

**Advanced Numerical Analysis: Practical (SEE: 30*; IA: 08)**

(*Laboratory Assignment = 5 marks + Viva- Voce = 5 marks
+ Compilation and Execution of Two Problems = 20 marks).

2. Graeffe’s Root-squaring method (up to biquadratic).
3. Bairstow’s method (up to biquadratic).
10. Cubic Spline interpolation using the General Form.
11. Integral equation: Monte–Carlo method.

**Practical Examination Related Criteria:**

(i) Laboratory clearance be taken by the students prior to commencement of practical examination.
(ii) The Lab. Assignment Dissertations of the students be submitted prior to commencement of practical examination.
(iii) Duration of practical examination will be 4 (Four) hours.
(iv) One external examiner be appointed for practical examination.

**References:**

2. Balaguruswamy, E.: Programming in ANSI C.

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Contd..
Optional Subject
Compressible Fluid Dynamics
(Applied Stream)
Marks: 100 (SEE: 80; IA: 20)


Isentropic Flow: Governing equations, Effect of Area Variation, Nozzle, Diffuser, Choking, Isentropic Flow Relations, Differential Equations in terms of Area variation and Solution.


References:
1. Thompson, P. A., Compressible Fluid Dynamics.

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The Head of the Department of Mathematics

Contd..
4. Oswatitsch, K., Gas Dynamics.

Optional Subjects for Only Pure Stream

Optional Subject
Advanced Real Analysis
(Pure Stream)
Marks : 100 (SEE: 80; IA: 20)


Vitali’s covering theorem. Differentiability of monotone functions and of functions of bounded variation. Absolutely continuous functions, Lusin’s condition (N), characterization of AC functions in terms of VB functions and Lusin’s condition. (6)

Concepts of VB*, AC*, VBG*, ACG* etc. functions. Characterization of indefinite Lebesgue integral as an absolutely continuous function. (6)


Definition and elementary properties of the Perron integral and its equivalence with the Henstock integral. (6)

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Contd..
Definition of the (special) Denjoy integral and its equivalence with the Henstock integral
(characterization of indefinite Henstock integral as a continuous ACG* function). (4)
Density of arbitrary sets. Approximate continuity. Approximate derivative. (4)

References:
5. R. Henstock: Lectures on the Theory of Integration.

Optional Subject
Advanced Partial Differential Equations
(Pure Stream)
Marks: 100 (SEE: 80; IA: 20)
Common linear PDEs and their boundary conditions Cauchy data and the Cauchy-Kowalewski expansion, Weak solutions of linear PDEs Well-posedness, Classification of PDEs and PDE systems from their principal symbol, (5)
Parabolic PDE, Heat Equation in \( \mathbb{R}^n \), Fundamental solution, Heat ball, Maximum Principle. (5)
Hyperbolic PDE in \( \mathbb{R}^n \), Scalar conservation laws and the Riemann problem Generalized functions and the delta-function (10)
Hamilton Jacobi Equation, Elliptic PDE, Green's functions for ODEs Green's functions for applications in Laplace, Poisson and Helmholtz equations , Review of harmonic functions, Extension of maximum principles (15) 

Variational problems. Euler Lagrange equations,(10)

Introduction to sobolev space.(5)

Solution of PDE by Finite element method Using MATLAB.(10)

References.
Barros-Neto- An introduction to the Introduction to the Theory of Distributions
Adams- Sobolev Spaces,
Kesavan - Topics in Functional Analysis and Applications
Evans - Partial Differential Equations
H.Brezis-AnalyseFonctionnelle

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Optional Subject

Advanced Complex Analysis – I  
(Pure Stream)

Marks : 100 (SEE: 80; IA: 20)

The functions- M(r) and A(r). Hadamard theorem on the growth of log M(r), Schwarz inequality, Borel-Caratheodory inequality, Open mapping theorem. (10)

Dirichlet series, abscissa of convergence and abscissa of absolute convergence, their representations in terms of the coefficients of the Dirichlet series. The Riemann Zeta function, the product development and the zeros of the zeta functions. (10)

Entire functions, growth of an entire function, order and type and their representations in terms of the Taylor coefficients, distribution of zeros. Schottky’s theorem (no proof). Picard’s first theorem. Weierstrass factor theorem, the exponent of convergence of zeros. Hadamard’s factorization theorem, Canonical product, Borel’s first theorem. Borel’s second theorem (statement only). (16)

Multiple-valued functions, Riemann surface for the functions $\sqrt{z}$, logz (3)

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The Head of the Department of Mathematics

Contd..
Analytic continuation, uniqueness, continuation by the method of power series, natural boundary, existence of singularity on the circle of convergence. Functions element, germ and complete analytic functions. Monodormy theorem.

Conformal transformations, Riemann’s theorems for circle, Schwarz principle of symmetry, Schwarz-Christoffel formula (statement only) with applications.

Univalent functions, general theorems, sequence of univalent functions, sufficient conditions for univalence.

References:
5. J. B. Conway: Functions of One Complex Variable.

Optional Subject
Advanced Complex Analysis – II
(Pure Stream)
Marks: 100 (SEE: 80; IA: 20)

Harmonic functions, Characterisation of Harmonic functions by mean-value property.
Poisson’s integral formula. Dirichlet problem for a disc.
Doubly periodic functions. Weierstrass Elliptic function.
Entire functions, M(r,f) and its properties (statements only). Meromorphic functions.
Expansions. Definition of the functions m (r, a), N(r, a) and T(r,f).


References:
4. W. Kaplan, An Introduction to Analytic Functions.
7. L. Yang, Value Distribution Theory.
8. R. C. Gunning and H. Rossi, Analytic Functions of Several Complex Variables.

Optional Subject
Advanced Functional Analysis
Complete orthonormal sequence and separability in Hilbert spaces. Complete orthonormal sequence in $L[0, 2\pi]$, Isometric isomorphism of every infinite dimensional separable Hilbert space with the space $l_2$.

The weak* topology of the conjugate of a normal space, Banach-Alaoglu theorem. Annihilators of subspaces of $X$ and $X^*$, where $X$ is a Banach space ; Conjugates of subspaces and of quotient spaces of $X$. The Krein-Milman theorem on extreme points in normed spaces.

Representation theorems for bounded linear functionals on $C[a, b]$ and on $\ell_p$ ($1 \leq p < +\infty$).

Stone-Weiestrass theorem, Approximation in normed spaces, Best approximation, and uniqueness.


Gateaux derivative, uniqueness, representation when domain and range are finite dimensional. Frechet derivative, relation with Gateaux derivative, and complete continuity of Frechet derivative.

References:
2. S. Berberian : Introduction to Hilbert Spaces.

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Optional Subject
Set-Valued Analysis
(Pure Stream)
Marks: 100 (SEE: 80; IA: 20)

Upper limit and Lower limit, and Limit of sequences of sets in metric spaces; Basic properties and examples. Calculus of upper and lower limits. Zorankiewicz’s compactness theorem in separable metric spaces. (10)

Set-valued maps (Multifunctions); their graph, domain, image, inverse. Inverse image and Core of a set by a set-valued map. The operations of union, intersection, difference, vector sum (in vector spaces), composition product and square product of set-valued maps; their basic properties. (14)


Closed convex processes in normed spaces; Open mapping theorem, Closed graph theorem, Uniform boundedness theorem. (5)

Contingent cone, Adjacent cone and Circatangent cone to subsets of normed spaces; their basic properties. Special properties of the tangent cones to convex sets. Contingent derivative. Adjacent derivative and circatangent derivative of set-valued maps in normed spaces; Their basic properties and expressions as limits of differential quotients. (16)
References:
2. K. Kuratowski: Topologie.

Optional Subject

Abstract Harmonic Analysis
(Pure Stream)
Marks: 100 (SEE: 80; IA: 20)

Locally compact groups: Harr measure, Unimodular group, Homogeneous spaces.
Representation Theory: Unitary representation, Representation of a group and its group algebra, Functions of positive type.
Analysis on Locally compact groups: Dual group, Fourier transform, Potriagin duality.
Analysis on Compact groups: Representation of Compact groups, The Peter-Weyl Theorem.

References:
1. A Course in Abstract Harmonic Analysis, G. B. Folland
3. L. Loomis: An Introduction to Abstract Harmonic Analysis.

Optional Subject

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The Head of the Department of Mathematics
Contd..
Locally Connected space, Various Disconnected spaces, and Quotient Spaces: Local Connected spaces, Zero-dimensional spaces, totally and extremally disconnected spaces, characterizations and their basic properties. Quotient spaces. (6)

Nets and Filters: Inadequacy of sequence, Directed set, definition of net, convergence by net. Cluster point of a net, subnet, ultranet, Topological concepts via nets. (5)


Embedding and Metrization: Evaluation map, Embedding theorem for Tychonoff spaces, Urysohn’s metrization theorem. (5)


Proximity spaces: Definition and examples. Topology induced by proximity. Alternate description of proximity (the concept of $\delta$-neighbourhood). Separated proximilarities. Proximal
neighbourhoods. p-map, p-isomorphism. Subspaces and product of proximity spaces. Proximities induced by uniformities. Compactness and proximities. (5)

C(X) and C*(X) : The function rings C(X) and C*(X), C-embedded and C* embedded sets in X. Urysohn’s extension theorem, Z-filters and Z-ultrafilters on X, their duality with ideals and maximal ideals of C(X). Fixed ideals and compact spaces. (9)

References:
2. S. Willard : General Topology.
3. J. Dugundji, Topology.
7. L. Gillman and M. Jerison : Rings of continuous functions.

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Optional Subject

Advanced Algebraic Topology
(Pure Stream)
Marks : 100 (SEE: 80; IA: 20)


Higher Homotopy Groups : Basic properties and examples. Homotopy Groups of Spheres. Relation between homology groups and homotopy groups. Lefschetz fixed point theorem. Brouwer fixed point theorem. (15)

Singular Homology Theory : Singular Chain Complex. Singular Homology group. Chain map, induced map between homology groups. Chain homotopy, Mayer-Victoris sequences. Axioms for homology theorem. (15)

Cohomology and Duality Theorems : Definitions and Calculation Theorems. Poincaré duality. Alexander duality and Lefschetz duality. (8)

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Contd..

**References**:

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**Optional Subject**

**Optional Subject**

**Advanced Algebra –I**

(Pure Stream)

**Marks: 100 (SEE: 80; IA : 20)**

Ideals and Bi-ideals: Definitions, related concepts of semi groups and rings, their different types of classifications and generalizations-relevant results, Fuzzy and Anti fuzzy algebraic treatment of them. (20)

Finite field and filed extensions: Definitions and study of important properties-related results and their verifications with examples. (20)

Geometric Constructions: Constructible Real Numbers, Trisection of 60º Angle and square the circle by straight edge and compass. Duplication of a cube. Construction of a Regular Septagon. Constructibility of Regular 9-gon and regular 20-gon. (10)

Advanced module theory: Review of different kinds of modules-some advanced theories, products and co-products, injective modules, tensor products, modules over a principal ideal domains, finitely generated abelian groups. (10)

Semi groups: Review of earlier related concepts, idea of regular semi groups, completely regular semi groups, intra regular semi groups etc and their related properties, semi lattices of groups. (10)

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Contd..
Coding Theory: Idea and simple theories. (2)

References:
2. T. W. Hungerford: Algebra

Optional Subject
Advanced Algebra – II
(Pure Stream)
Marks: 100 (SEE: 80; IA: 20)


Modules over PID, Torsion-free modules, Finitely generated modules over PID. (4)
Tensor product of modules, Tensor product of free modules. (5)

Commutative Rings and Modules: Noetherian and Artinian modules, Composition series in modules. Primary decomposition of a submodule of a module. (7)

Noetherian rings, Cohen’s theorem, Krull intersection theorem, Nakayama lemma. Hilbert basis theorem. (5)

Extension of a ring, Integral extension of a ring, Integral closure, Lying-over and Going-up theorems. (3)

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The Head of the Department of Mathematics
Contd..
Transcendence base of a field over a subfield. Algebraically independence subset of an extension field over a field. Algebraically closed field extensions of isomorphic fields with equal transcendence degree are isomorphic. (5)

Affine varieties of algebraic sets. Noether normalization lemma, Hilbert Nullstellensatz. (5)

**Structure of Rings**: Left artinian rings, Simple rings, Primitive rings, Jacobson density theorem, Wedderburn Artin theorem on simple (left), Artinian rings. (5)

The Jacobson radical, Jacobson semisimple rings, subdirect product of rings, Jacobson semisimple rings as subdirect products of primitive rings, Wedderburn-Artin theorem on Jacobson semisimple (left), Artinian rings. (6)

Simple and Semisimple modules, Semisimple rings, Equivalence of semisimple rings with Jacobson (left) Artinian rings, Properties of semisimple rings, Characterizations of semisimple rings in terms of modules. (4)

**Group Representations**: Group rings, Maschkke’s theorem, Character of a representation, Regular representations, Orthogonality relations, Burnside’s $p^aq^b$ theorem. (10)

**References**:

17. I. N. Herstein : Non-Commutative Rings.

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**Optional Subject**

**Advanced Geometry – I**

(Pure Stream)

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Contd..
Manifold Theory: Differentiable manifold, Differentiable mapping, Differentiable transformations, Diffeomorphism, Vector field, Integral curve of a vector field, Lie bracket, Immersion, Imbedding, rank of a mapping, f-related vector fields. Total differential of a function. Lie groups.

Geodesics, Convex neighbourhood, Geodesic flow, Minimizing properties of geodesics, convex neighbourhood.

Riemannian Manifolds: Affine connections, Riemannian connections, semi symmetric connections, fibre bundle Basic definitions, Curvature tensor, Ricci tensor, Scalar curvature, Sectional curvature, Properties of Riemann curvature tensor, Bianchi’s identities, Conformal curvature tensor, Projective curvature tensor, Jacobi equations Local Isometrics, Lie Derivatives and their elementary properties.


Spaces of constant curvature, Theorem of Cartan, Hyperbolic spaces, Formulas for the first and second variation of energy.

References:
1. N. J. Hicks: Notes on Differential Geometry.
2. Riemannian Geometry, M. P. Do carmo.
5. W. M. Boothby: An Introduction to Differentiable Manifold and Riemannian Geometry.
8. U. C. De and A. A. Sheikh: Geometry of Differentiable Manifolds.

**Contact Manifolds**: Definition and examples of contact manifolds. Almost contact manifolds. K-contact and Sasakian structures. Sasakian space forms. Nearly Sasakian structures. (15)


**References**:
2. R. S. Mishra: Structures on a Differentiable Manifold and their Application.
5. R. Resnik: Introduction to Special Relativity.

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**Optional Subject**

**Ergodic Theory and Topological Dynamics**

(Pure Stream)

**Marks**: 100 (SE: 80; IA: 20)

**Measure Preserving Transformation**: Definition and Examples, Recurrence, Ergodicity.
The Ergodic Theorem: Von Neumann’s L2-ergodic Theorem, Birkhoff’s Ergodic Theorem, Disintegrating a measure space over a factor algebra.


Entropy: Partitions and Subalgebras, Entropy of a Partition, Conditional Entropy, Entropy of a measure preserving transformation, Properties of \( h(T,A) \), \( h(T) \), some methods for calculating \( h(T) \), How Good an Invariant is Entropy, Bernoulli Automorphisms and Kolmogorov Automorphisms, The Pinsker \( \sigma \)-Algebra of a Measure Preserving Transformation, Sequence Entropy.

Topological Dynamics: Recurrent points, Uniform Recurrence and Minimal Systems, Multiple Birkhoff recurrence Theorem and its applications

References:
1. H. Furstenberg, Recurrence in ergodic Theory and combinatorial applications
3. Peter Walters, An introduction to ergodic theory.
4. M. Einsiedler and Tomas Ward, Ergodic Theory with a view towards number theory

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