UNIVERSITY OF CALCUTTA

Notification No. CSR/ 12 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 28.05.2018 (vide Item No.14) approved the Syllabi of different subjects in Undergraduate Honours / General / Major courses of studies (CBCS) under this University, as laid down in the accompanying pamphlet:

List of the subjects

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subject</th>
<th>Sl. No.</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anthropology (Honours / General)</td>
<td>29</td>
<td>Mathematics (Honours / General)</td>
</tr>
<tr>
<td>2</td>
<td>Arabic (Honours / General)</td>
<td>30</td>
<td>Microbiology (Honours / General)</td>
</tr>
<tr>
<td>3</td>
<td>Persian (Honours / General)</td>
<td>31</td>
<td>Mol. Biology (General)</td>
</tr>
<tr>
<td>4</td>
<td>Bengali (Honours / General / LCC2 / AECC1)</td>
<td>32</td>
<td>Philosophy (Honours / General)</td>
</tr>
<tr>
<td>5</td>
<td>Bio-Chemistry (Honours / General)</td>
<td>33</td>
<td>Physical Education (General)</td>
</tr>
<tr>
<td>6</td>
<td>Botany (Honours / General)</td>
<td>34</td>
<td>Physics (Honours / General)</td>
</tr>
<tr>
<td>7</td>
<td>Chemistry (Honours / General)</td>
<td>35</td>
<td>Physiology (Honours / General)</td>
</tr>
<tr>
<td>8</td>
<td>Computer Science (Honours / General)</td>
<td>36</td>
<td>Political Science (Honours / General)</td>
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<tr>
<td>9</td>
<td>Defence Studies (General)</td>
<td>37</td>
<td>Psychology (Honours / General)</td>
</tr>
<tr>
<td>10</td>
<td>Economics (Honours / General)</td>
<td>38</td>
<td>Sanskrit (Honours / General)</td>
</tr>
<tr>
<td>11</td>
<td>Education (Honours / General)</td>
<td>39</td>
<td>Social Science (General)</td>
</tr>
<tr>
<td>12</td>
<td>Electronics (Honours / General)</td>
<td>40</td>
<td>Sociology (Honours / General)</td>
</tr>
<tr>
<td>13</td>
<td>English ((Honours / General / LCC1/ LCC2/AECC1)</td>
<td>41</td>
<td>Statistics (Honours / General)</td>
</tr>
<tr>
<td>14</td>
<td>Environmental Science (Honours / General)</td>
<td>42</td>
<td>Urdu (Honours / General / LCC2 / AECC1)</td>
</tr>
<tr>
<td>15</td>
<td>Environmental Studies (AECC2)</td>
<td>43</td>
<td>Women Studies (General)</td>
</tr>
<tr>
<td>16</td>
<td>Film Studies (General)</td>
<td>44</td>
<td>Zoology (Honours / General)</td>
</tr>
<tr>
<td>17</td>
<td>Food Nutrition (Honours / General)</td>
<td>45</td>
<td>Industrial Fish and Fisheries – IFFV (Major)</td>
</tr>
<tr>
<td>18</td>
<td>French (General)</td>
<td>46</td>
<td>Sericulture – SRTV (Major)</td>
</tr>
<tr>
<td>19</td>
<td>Geography (Honours / General)</td>
<td>47</td>
<td>Computer Applications – CMAV (Major)</td>
</tr>
<tr>
<td>20</td>
<td>Geology (Honours / General)</td>
<td>48</td>
<td>Tourism and Travel Management – TTMV (Major)</td>
</tr>
<tr>
<td>21</td>
<td>Hindi (Honours / General / LCC2 / AECC1)</td>
<td>49</td>
<td>Advertising Sales Promotion and Sales Management – ASPV (Major)</td>
</tr>
<tr>
<td>22</td>
<td>History (Honours / General)</td>
<td>50</td>
<td>Communicative English – CMEV (Major)</td>
</tr>
<tr>
<td>23</td>
<td>Islamic History Culture (Honours / General)</td>
<td>51</td>
<td>Clinical Nutrition and Dietetics CNDV (Major)</td>
</tr>
<tr>
<td>24</td>
<td>Home Science Extension Education (General)</td>
<td>52</td>
<td>Bachelor of Business Administration (BBA) (Honours)</td>
</tr>
<tr>
<td>25</td>
<td>House Hold Art (General)</td>
<td>53</td>
<td>Bachelor of Fashion and Apparel Design – (B.F.A.D.) (Honours)</td>
</tr>
<tr>
<td>26</td>
<td>Human Development (Honours / General)</td>
<td>54</td>
<td>Bachelor of Fine Art (B.F.A.) (Honours)</td>
</tr>
<tr>
<td>27</td>
<td>Human Rights (General)</td>
<td>55</td>
<td>B. Music (Honours / General) and Music (General)</td>
</tr>
<tr>
<td>28</td>
<td>Journalism and Mass Communication (Honours / General)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 4th June, 2018

(Dr. Santanu Paul)
Deputy Registrar
University of Calcutta
Syllabus for three-year B.Sc. in Mathematics
(Honours)

under
CBCS System

2018
1. Credit Distribution across Courses

<table>
<thead>
<tr>
<th>Course Type</th>
<th>Total Papers</th>
<th>Theory + Tutorial</th>
<th>Theory + Practical</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Core Courses</td>
<td>14</td>
<td>$13 \times 5 = 65$</td>
<td>$1 \times 4 = 4$</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$13 \times 1 = 13$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discipline Specific Electives</td>
<td>4</td>
<td>$4 \times 5 = 20$</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$4 \times 1 = 4$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generic Electives</td>
<td>4</td>
<td>$4 \times 6 = 24$</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Ability Enhancement Language Courses</td>
<td>2</td>
<td>$2 \times 2 = 4$</td>
<td></td>
<td>4</td>
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<tr>
<td>Skill Enhancement Courses</td>
<td>2</td>
<td>$2 \times 2 = 4$</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>26</strong></td>
<td><strong>134</strong></td>
<td><strong>6</strong></td>
<td><strong>140</strong></td>
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</table>

2. Course Structure : Semester-wise distribution of Courses

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Name</th>
<th>Course Detail</th>
<th>Credits</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ability Enhancement Compulsory Course-1</td>
<td>AECC(1)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Core Course-1</td>
<td>Calculus, Geometry &amp; Vector Analysis</td>
<td>6</td>
<td>4</td>
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<tr>
<td></td>
<td>Core Course-2</td>
<td>Algebra</td>
<td>6</td>
<td>6</td>
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<td></td>
<td>Generic Elective-1</td>
<td>GE(1)/CC(1) *</td>
<td>6</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>20</strong></td>
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<tr>
<td>2</td>
<td>Ability Enhancement Compulsory Course-2</td>
<td>AECC(2)</td>
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<td></td>
<td>Core Course-3</td>
<td>Real Analysis</td>
<td>6</td>
<td>8</td>
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<td>Core Course-4</td>
<td>Group Theory-I</td>
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<td>Generic Elective-2</td>
<td>GE(2)/CC(2) *</td>
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<td></td>
<td><strong>20</strong></td>
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<td>3</td>
<td>Core Course-5</td>
<td>Theory of Real Functions</td>
<td>6</td>
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<td>Core Course-6</td>
<td>Ring Theory &amp; Linear Algebra-I</td>
<td>6</td>
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<td>Core Course-7</td>
<td>ODE &amp; Multivariate Calculus-I</td>
<td>6</td>
<td>14</td>
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<td></td>
<td>Skill Enhancement Course-A</td>
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<td>2</td>
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<td>Generic Elective-3</td>
<td>GE(3)/CC(3) *</td>
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<td>4</td>
<td>Core Course-8</td>
<td>Riemann Integration &amp; Series of Functions</td>
<td>6</td>
<td>16</td>
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<td>Core Course-9</td>
<td>PDE &amp; Multivariate Calculus-II</td>
<td>6</td>
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<td>Core Course-10</td>
<td>Mechanics</td>
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<td>Skill Enhancement Course-B</td>
<td>See SEC B</td>
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<td>Generic Elective-4</td>
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<td>5</td>
<td>Core Course-11</td>
<td>Probability &amp; Statistics</td>
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<td>22</td>
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<td>Core Course-12</td>
<td>Group Theory-II &amp; Linear Algebra-II</td>
<td>6</td>
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<td></td>
<td>Discipline Specific Elective- A</td>
<td>See DSE A(1)</td>
<td>6</td>
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<tr>
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<td>Discipline Specific Elective-B</td>
<td>See DSE B (1)</td>
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<td><strong>24</strong></td>
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<tr>
<td>6</td>
<td>Core Course-13</td>
<td>Metric Space &amp; Complex Analysis</td>
<td>6</td>
<td>26</td>
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<td></td>
<td>Core Course-14</td>
<td>Numerical Methods</td>
<td>4</td>
<td>28</td>
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<td></td>
<td>Core Course-14 Practical</td>
<td>Numerical Methods Lab</td>
<td>2</td>
<td>30</td>
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<td></td>
<td>Discipline Specific Elective- A</td>
<td>See DSE A(2)</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Discipline Specific Elective-B</td>
<td>See DSE B(2)</td>
<td>6</td>
<td>3</td>
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<td><strong>24</strong></td>
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<td></td>
<td><strong>Grand Total</strong></td>
<td></td>
<td><strong>140</strong></td>
<td></td>
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</tbody>
</table>

*These courses are to be taken by the students of other discipline. These are the 4 Core Courses of General Courses of other disciplines.
3. Choices for Discipline Specific Electives (DSE)

<table>
<thead>
<tr>
<th>DSE-A(1)</th>
<th>DSE-B(1)</th>
<th>DSE-A(2)</th>
<th>DSE-B(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Semester -5</td>
<td>For Semester-5</td>
<td>For Semester-6</td>
<td>For Semester-6</td>
</tr>
<tr>
<td>Bio Mathematics [32]</td>
<td>Linear Programming</td>
<td>Mathematical Modelling</td>
<td>Astronomy</td>
</tr>
<tr>
<td></td>
<td>&amp; Game Theory [37]</td>
<td></td>
<td>&amp; Space Science [47]</td>
</tr>
<tr>
<td>[34]</td>
<td>&amp; Automata Theory [39]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# The number within the bracket [ ] refers to page number. A student has to opt for any one of the subjects in DSE-A(1) and any one in DSE-B(1) in Semester 5. The student has to opt for any one of the subjects in DSE-A(2) and any one in DSE-B(2) in Semester 6.

4. Choices for Skill Enhancement Courses (SEC)

<table>
<thead>
<tr>
<th>SEC-A (for Semester 3)</th>
<th>SEC-B (for Semester 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Programming Language [51]</td>
<td>Mathematical Logic [53]</td>
</tr>
<tr>
<td>Object Oriented Programming in C++ [52]</td>
<td>Scientific computing with SageMath &amp; R [54]</td>
</tr>
</tbody>
</table>

# The number within the bracket [ ] refers to page number. A student has to opt for any one of the subjects available under each category.
Calculus, Geometry & Vector Analysis

<table>
<thead>
<tr>
<th>Semester : 1</th>
<th>Credits : 5+1*=6</th>
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</thead>
<tbody>
<tr>
<td>Core Course-1</td>
<td>Full Marks : 65+15**+20***=100</td>
</tr>
<tr>
<td>Number of classes required : 75</td>
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</tr>
</tbody>
</table>

**1 Credit for Tutorial

**15 Marks are reserved for Tutorial

***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Course Structure

Unit-1 : Calculus

- Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}$sin x, $e^{ax+b}$cos x, $(ax+b)^n$ sin x, $(ax+b)^n$ cos x, curvature, concavity and points of inflection, envelopes, rectilinear asymptotes (Cartesian & parametric form only), curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L’Hospital’s rule, applications in business, economics and life sciences.

- Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n xdx$, $\int \cos^n xdx$, $\int \tan^n xdx$, $\int \sec^n xdx$, $\int (\log x)^n dx$, $\int \sin^n x \sin mx dx$, $\int \sin^n x \cos^m x dx$. Parametric equations, parametrizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution.

Unit-2 : Geometry

- Rotation of axes and second degree equations, classification of conics using the discriminant, tangent and normal, polar equations of conics.


- Straight lines in 3D: Equation (Symmetric & Parametric form). Direction ratio and direction cosines. Canonical equation of the line of intersection of two intersecting planes. Angle between two lines. Distance of a point from a line. Condition of coplanarity of two lines. Equation of skew lines. Shortest distance between two skew lines.

- Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid. Tangent and normals of conicoids.

Unit-3 : Vector Analysis

- Triple product, vector equations, applications to geometry and mechanics — concurrent forces in a plane, theory of couples, system of parallel forces. Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions of one variable.

Graphical Demonstration (Teaching Aid**)

- Plotting of graphs of function $e^{ax+b}$, log$(ax+b)$, $1/(ax+b)$, sin$(ax+b)$, cos$(ax+b)$, $|ax+b|$ and to illustrate the effect of a and b on the graph.
• Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.

• Sketching parametric curves (Eg. trochoid, cycloid, epicycloids, hypocycloid).

• Obtaining surface of revolution of curves.

• Tracing of conics in cartesian coordinates/ polar coordinates.

• Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using cartesian coordinates.

** Preferably by free softwares but can be taught through drawing on black board/white board etc. in case of unavailability.

References

Algebra

<table>
<thead>
<tr>
<th>Semester : 1</th>
<th>Credits : 5+1* = 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Course-2</td>
<td>Full Marks : 65+15**+20*** = 100</td>
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<tr>
<td>Number of classes required : 75</td>
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</tbody>
</table>

*1 Credit for Tutorial
**15 Marks are reserved for Tutorial
***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Unit-1

[30 classes]

- Polar representation of complex numbers, \( n \)-th roots of unity, De Moivre’s theorem for rational indices and its applications. Exponential, logarithmic, trigonometric and hyperbolic functions of complex variable.
- Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, Sturm’s theorem, cubic equation (solution by Cardan’s method) and biquadratic equation (solution by Ferrari’s method).
- Inequality: The inequality involving \( AM \geq GM \geq HM \), Cauchy-Schwartz inequality.
- Linear difference equations with constant coefficients (up to 2nd order).

Unit-2

[30 classes]

- Mapping: injective, surjective, one to one correspondence, invertible mapping, composition of mappings, relation between composition of mappings and various set theoretic operations. Meaning and properties of \( f^{-1}(B) \), for any mapping \( f : X \to Y \) and \( B \subseteq Y \).
- Well-ordering property of positive integers, Principles of Mathematical induction, division algorithm, divisibility and Euclidean algorithm. Prime numbers and their properties, Euclid’s theorem. Congruence relation between integers. Fundamental Theorem of Arithmetic. Chinese remainder theorem. Arithmetic functions, some arithmetic functions such as \( \phi, \tau, \sigma \) and their properties.

Unit-3

[15 classes]

- Rank of a matrix, inverse of a matrix, characterizations of invertible matrices.
- Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation \( AX = B \), solution sets of linear systems, applications of linear systems.

References


Real Analysis

<table>
<thead>
<tr>
<th>Semester : 2</th>
<th>Credits : 5+1* = 6</th>
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</thead>
<tbody>
<tr>
<td>Core Course-3</td>
<td>Full Marks : 65+15**+20*** = 100</td>
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</table>

Number of classes required : 75

*1 Credit for Tutorial

**15 Marks are reserved for Tutorial

***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Course Structure

<table>
<thead>
<tr>
<th>Unit-1</th>
<th>[30 classes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Intuitive idea of real numbers. Mathematical operations and usual order of real numbers revisited with their properties (closure, commutative, associative, identity, inverse, distributive). Idea of countable sets, uncountable sets and uncountability of ( \mathbb{R} ). Concept of bounded and unbounded sets in ( \mathbb{R} ). L.U.B. (supremum), G.L.B. (infimum) of a set and their properties. L.U.B. axiom or order completeness axiom. Archimedean property of ( \mathbb{R} ). Density of rational (and Irrational) numbers in ( \mathbb{R} ).</td>
<td></td>
</tr>
<tr>
<td>• Intervals. Neighbourhood of a point. Interior point. Open set. Union, intersection of open sets. Limit point and isolated point of a set. Bolzano-Weirstrass theorem for sets. Existence of limit point of every uncountable set as a consequence of Bolzano-Weirstrass theorem. Derived set. Closed set. Complement of open set and closed set. Union and intersection of closed sets as a consequence. No nonempty proper subset of ( \mathbb{R} ) is both open and closed. Dense set in ( \mathbb{R} ) as a set having non-empty intersection with every open intervals. ( \mathbb{Q} ) and ( \mathbb{R} \setminus \mathbb{Q} ) are dense in ( \mathbb{R} ).</td>
<td></td>
</tr>
</tbody>
</table>

Unit-2

<table>
<thead>
<tr>
<th>[30 classes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Relation between the limit point of a set and the limit of a convergent sequence of distinct elements. Monotone sequences and their convergence. Sandwich rule. Nested interval theorem. Limit of some important sequences: ( \left{ \frac{1}{n} \right}_n ), ( \left{ x^n \right}_n ), ( \left{ x_n \right}<em>n ) with ( x</em>{n+1} - x_n \rightarrow l ) and (</td>
</tr>
<tr>
<td>• Subsequence. Subsequential limits, ( \lim \sup ) as the L.U.B. and ( \lim \inf ) as the G.L.B of a set containing all the subsequential limits. Alternative definition of limsup and liminf of a sequence using inequality or as ( \lim \sup x_n = \inf \sup{x_n, x_{n+1}, \ldots} ) and ( \lim \inf x_n = \sup \inf{x_n, x_{n+1}, \ldots} ) [\text{[Equivalence between these definitions is assumed]}]. A bounded sequence ( {x_n} ) is convergent if and only if ( \lim \sup x_n = \lim \inf x_n ). Every sequence has a monotone subsequence. Bolzano-Weirstrass theorem for sequence. Cauchy’s convergence criterion. Cauchy sequence.</td>
</tr>
</tbody>
</table>

Unit-3

<table>
<thead>
<tr>
<th>[10 classes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Infinite series, convergence and non-convergence of infinite series, Cauchy criterion, tests for convergence : comparison test, limit comparison test, ratio test, Cauchy’s ( n )-th root test, Kummer’s test and Gauss test (statements only). Alternating series, Leibniz test. Absolute and conditional convergence.</td>
</tr>
</tbody>
</table>

Graphical Demonstration (Teaching aid**)  

<table>
<thead>
<tr>
<th>[5 classes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Plotting of recursive sequences.</td>
</tr>
</tbody>
</table>
• Study the convergence of sequences through plotting.
• Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
• Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
• Cauchy’s root test by plotting $n$-th roots.
• Ratio test by plotting the ratio of $n$-th and $(n + 1)$-th term.

** Preferably by computer softwares but can be taught through drawing on black board/white board etc. in case of unavailability.

References

Group Theory-I

| Semester : 2 | Credits : 5+1*=6 |
| Core Course-4 | Full Marks : 65+15**+20***=100 |
| Number of classes required : 75 |

*1 Credit for Tutorial

**15 Marks are reserved for Tutorial

***20 Mark are reserved for Internal Assessment

& Attendance (10 marks for each)

Unit-1

- Symmetries of a square, definition of group, examples of groups including permutation groups, dihedral groups and quaternion groups (through matrices), elementary properties of groups, examples of commutative and non-commutative groups. Subgroups and examples of subgroups, necessary and sufficient condition for a nonempty subset of a group to be a subgroup. Normalizer, centralizer, center of a group, product of two subgroups.

Unit-2

- Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, order of an element, order of a group. Lagrange’s theorem and consequences including Fermat’s Little theorem.

Unit-3

- Normal subgroup and its properties. Quotient group. Group homomorphisms, properties of homomorphisms, correspondence theorem and one one correspondence between the set of all normal subgroups of a group and the set of all congruences on that group, Cayley’s theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

References

Course Structure  |  DSE  |  SEC  |  Credit Distribution

**Unit-1 : Limit & Continuity of functions**

- Limits of functions ($\epsilon - \delta$ approach), sequential criterion for limits. Algebra of limits for functions, effect of limit on inequality involving functions, one sided limits. Infinite limits and limits at infinity. Important limits like $\frac{\sin x}{x}$, $\frac{\log(1+x)}{x}$, $a^x - 1$ ($a > 0$) as $x \to 0$.

- Continuity of a function on an interval and at an isolated point. Sequential criteria for continuity. Concept of oscillation of a function at a point. A function is continuous at $x$ if and only if its oscillation at $x$ is zero. Familiarity with the figures of some well known functions: $y = x^a$ ($a = 2, 3, \frac{1}{2}, -1$), $|x|$, $\sin x$, $\cos x$, $\tan x$, $\log x$, $e^x$. Algebra of continuous functions as a consequence of algebra of limits. Continuity of composite functions. Examples of continuous functions. Continuity of a function at a point does not necessarily imply the continuity in some neighbourhood of that point.

- Bounded functions. Neighbourhood properties of continuous functions regarding boundedness and maintenance of same sign. Continuous function on $[a, b]$ is bounded and attains its bounds. Intermediate value theorem.

- Discontinuity of functions, type of discontinuity. Step functions. Piecewise continuity. Monotone functions. Monotone functions can have only jump discontinuity. Monotone functions can have at most countably many points of discontinuity. Monotone bijective function from an interval to an interval is continuous and its inverse is also continuous.

- Uniform continuity. Functions continuous on a closed and bounded interval is uniformly continuous. A necessary and sufficient condition under which a continuous function on a bounded open interval $I$ will be uniformly continuous on $I$. A sufficient condition under which a continuous function on an unbounded open interval $I$ will be uniformly continuous on $I$ (statement only). Lipschitz condition and uniform continuity.

**Unit-2 : Differentiability of functions**

- Differentiability of a function at a point and in an interval, algebra of differentiable functions. Meaning of sign of derivative. Chain rule.

- Darboux theorem, Rolle’s theorem, Mean value theorems of Lagrange and Cauchy — as an application of Rolle’s theorem. Taylor’s theorem on closed and bounded interval with Lagrange’s and Cauchy’s form of remainder deduced from Lagrange’s and Cauchy’s mean value theorem respectively. Expansion of $e^x$, $\log(1+x)$, $(1+x)^m$, $\sin x$, $\cos x$ with their range of validity (assuming relevant theorems). Application of Taylor’s theorem to inequalities.

- Statement of L’ Hospital’s rule and its consequences. Point of local extremum (maximum, minimum) of a function in an interval. Sufficient condition for the existence of a local maximum/minimum of a function at a point (statement only). Determination of local extremum using first order derivative. Application of the principle of maximum/minimum in geometrical problems.
References


Unit-1 : Ring theory

- Definition and examples of rings, properties of rings, subrings, necessary and sufficient condition for a nonempty subset of a ring to be a subring, integral domains and fields, subfield, necessary and sufficient condition for a nonempty subset of a field to be a subfield, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms. First isomorphism theorem, second isomorphism theorem, third isomorphism theorem, Correspondence theorem, congruence on rings, one-one correspondence between the set of ideals and the set of all congruences on a ring.

Unit-2 : Linear algebra

- Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Subspaces of $\mathbb{R}^n$, dimension of subspaces of $\mathbb{R}^n$. Geometric significance of subspace.

References

Ordinary Differential Equation & Multivariate Calculus-I

<table>
<thead>
<tr>
<th>Semester</th>
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<th>Full Marks</th>
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Core Course-7
Paper Code(Theory): MTM-A-CC-3-7-TH
Paper Code (Tutorial):MTM-A-CC-3-7-TU

Number of classes required: 75

*1 Credit for Tutorial
**15 Marks are reserved for Tutorial
***20 Marks are reserved for Internal Assessment
& Attendance (10 marks for each)

Course Structure DSE SEC Credit Distribution

Unit-1: Ordinary differential equation

- First order differential equations: Exact differential equations and integrating factors, special integrating factors and transformations, linear equations and Bernoulli equations, the existence and uniqueness theorem of Picard (Statement only).
- Linear equations and equations reducible to linear form. First order higher degree equations solvable for x, y and p. Clairaut’s equations and singular solution.
- Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.
- System of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients.
- Planar linear autonomous systems: Equilibrium (critical) points, Interpretation of the phase plane and phase portraits.
- Power series solution of a differential equation about an ordinary point, solution about a regular singular point (up to second order).

Unit-2: Multivariate Calculus-I

- Concept of neighbourhood of a point in $\mathbb{R}^n$ ($n > 1$), interior point, limit point, open set and closed set in $\mathbb{R}^n$ ($n > 1$).
- Functions from $\mathbb{R}^n(n > 1)$ to $\mathbb{R}^m(m \geq 1)$, limit and continuity of functions of two or more variables. Partial derivatives, total derivative and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes. Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

References

[1] D.A. Murray, Introductory course in Differential Equations, Orient and Longman


Unit-1 : Riemann integration


- Concept of negligible set (or zero set) defined as a set covered by countable number of open intervals sum of whose lengths is arbitrary small. Examples of negligible sets: any subset of a negligible set, finite set, countable union of negligible sets. A bounded function on closed and bounded interval is Riemann integrable if and only if the set of points of discontinuity is negligible. Example of Riemann integrable functions.

- Integability of sum, scalar multiple, product, quotient, modulus of Riemann integrable functions. Properties of Riemann integrable functions arising from the above results.

- Function defined by definite integral \( \int_a^x f(t)dt \) and its properties. Antiderivative (primitive or indefinite integral). Properties of Logarithmic function defined as the definite integral \( \int_1^x \frac{dt}{t} \), \( x > 0 \).

- Fundamental theorem of Integral Calculus. First Mean Value theorem of integral calculus.

Unit-2 : Improper integral

- Range of integration, finite or infinite. Necessary and sufficient condition for convergence of improper integral in both cases.

- Tests of convergence: Comparison and M-test. Absolute and non-absolute convergence and inter-relations. Statement of Abel’s and Dirichlet’s test for convergence on the integral of a product.

- Convergence and working knowledge of Beta and Gamma function and their interrelation \( \left[ \Gamma(n)\Gamma(1-n) = \frac{n\pi}{\sin \pi n}, 0 < n < 1, \text{to be assumed} \right] \). Computation of the integrals \( \int_0^{\pi/2} \sin^n x dx \), \( \int_0^{\pi/2} \cos^n x dx \), \( \int_0^{\pi/2} \tan^n x dx \) when they exist (using Beta and Gamma function).

Unit-3 : Series of functions


• Fourier series : Trigonometric series. Statement of sufficient condition for a trigonometric series to be a Fourier series. Fourier coefficients for periodic functions defined on \([-\pi, \pi]\). Statement of Dirichlet’s condition of convergence. Statement of theorem of sum of Fourier series.

References


Unit-1 : Partial differential equation

- Partial differential equations of the first order, Lagrange’s solution, non linear first order partial differential equations, Charpit’s general method of solution, some special types of equations which can be solved easily by methods other than the general method.

- Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order linear equations to canonical forms.


Unit-2 : Multivariate Calculus-II

- Multiple integral: Concept of upper sum, lower sum, upper integral, lower-integral and double integral (no rigorous treatment is needed). Statement of existence theorem for continuous functions. Iterated or repeated integral, change of order of integration. Triple integral. Cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals. Transformation of double and triple integrals (problems only). Determination of volume and surface area by multiple integrals (problems only). Differentiation under the integral sign, Leibniz’s rule (problems only).

- Definition of vector field, divergence and curl. Line integrals, applications of line integrals : mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path.

- Green’s theorem, surface integrals, integrals over parametrically defined surfaces. Stoke’s theorem, The Divergence theorem.

References

Mechanics

| Semester : 4 | Credits : 5+1* = 6 |
| Core Course- 10 | Full Marks : 65+15**+20*** = 100 |
| Number of classes required : 75 |
| *1 Credit for Tutorial |
| **15 Marks are reserved for Tutorial |
| ***20 Marks are reserved for Internal Assessment |
| & Attendance (10 marks for each) |

Course Structure | DSE | SEC | Credit Distribution

Unit-1

• **Coplanar forces in general** : Resultant force and resultant couple, Special cases, Varignon’s theorem, Necessary and sufficient conditions of equilibrium. Equilibrium equations of the first, second and third kind.

• **An arbitrary force system in space** : Moment of a force about an axis, Varignon’s theorem. Resultant force and resultant couple, necessary and sufficient conditions of equilibrium. Equilibrium equations, Reduction to a wrench, Poinset’s central axis, intensity and pitch of a wrench, Invariants of a system of forces. Statically determinate and indeterminate problems.

• **Equilibrium in the presence of sliding Friction force** : Contact force between bodies, Coulomb’s laws of static friction and dynamic friction. The angle and cone of friction, the equilibrium region.

Unit-2

• **Virtual work** : Workless constraints - examples, virtual displacements and virtual work. The principle of virtual work, Deductions of the necessary and sufficient conditions of equilibrium of an arbitrary force system in plane and space, acting on a rigid body.

• **Stability of equilibrium** : Conservative force field, energy test of stability, condition of stability of a perfectly rough heavy body lying on a fixed body. Rocking stones.

Unit-3

• **Kinematics of a particle** : velocity, acceleration, angular velocity, linear and angular momentum. Relative velocity and acceleration. Expressions for velocity and acceleration in case of rectilinear motion and planar motion - in Cartesian and polar co-ordinates, tangential and normal components. Uniform circular motion.

• **Newton laws of motion and law of gravitation** : Space, time, mass, force, inertial reference frame, principle of equivalence and g. Vector equation of motion.

  Work, power, kinetic energy, conservative forces - potential energy. Existence of potential energy function. Energy conservation in a conservative field. Stable equilibrium and small oscillations: Approximate equation of motion for small oscillation. Impulsive forces

Unit-4

• **Problems in particle dynamics** : Rectilinear motion in a given force field - vertical motion under uniform gravity, inverse square field, constrained rectilinear motion, vertical motion under gravity in a resisting medium, simple harmonic motion, Damped and forced oscillations, resonance of an oscillating system, motion of elastic strings and springs.
• **Planar motion of a particle**: Motion of a projectile in a resisting medium under gravity, orbits in a central force field, Stability of nearly circular orbits. Motion under the attractive inverse square law, Kepler’s laws on planetary motion. Slightly disturbed orbits, motion of artificial satellites. Constrained motion of a particle on smooth and rough curves. Equations of motion referred to a set of rotating axes.

• **Motion of a particle in three dimensions**: Motion on a smooth sphere, cone, and on any surface of revolution.

**Unit-5**

• **Many particles system**
  
  **The linear momentum principle**: Linear momentum, linear momentum principle, motion of the centre of mass, conservation of linear momentum.

• **The angular momentum principle**: Moment of a force about a point, about an axis. Angular momentum about a point, about an axis. Angular momentum principle about centre of mass. Conservation of angular momentum (about a point and an axis). Impulsive forces.

• **The energy principle**: Configurations and degrees of freedom of a multi-particle system, energy principle, energy conservation.
  
  Rocket motion in free space and under gravity, collision of elastic bodies. The two-body problem.

**References**

[3] Mary Lunn; A First Course in Mechanics, OUP
[10] Timoshenko and Young, Engineering Mechanics, Mcgraw Hill

**Course Structure**

<table>
<thead>
<tr>
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<th>Credit Distribution</th>
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<tbody>
<tr>
<td>21</td>
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</table>
Course Structure

Unit-1
- Random experiment, $\sigma$-field, Sample space, probability as a set function, probability axioms, probability space. Finite sample spaces. Conditional probability, Bayes theorem, independence. Real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function. Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, Continuous distributions: uniform, normal, exponential.

Unit-2
- Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, moments, covariance, correlation coefficient, independent random variables, joint moment generating function (jmgf) and calculation of covariance from jmgf, characteristic function. Conditional expectations, linear regression for two variables, regression curves. Bivariate normal distribution.

Unit-3
- Markov and Chebyshev’s inequality, Convergence in Probability, statement and interpretation of weak law of large numbers and strong law of large numbers. Central limit theorem for independent and identically distributed random variables with finite variance.

Unit-4
- Sampling and Sampling Distributions: Populations and Samples, Random Sample, distribution of the sample, Simple random sampling with and without replacement. Sample characteristics.
- Sampling Distributions: Statistic, Sample moments. Sample variance, Sampling from the normal distributions, Chi-square, $t$ and $F$-distributions, sampling distribution of $\bar{X}$, $s^2$, $\frac{\sqrt{n}}{s}(\bar{X} - \mu)$
- Method of Maximum likelihood: likelihood function, ML estimators for discrete and continuous models.

Unit-5
- Statistical hypothesis: Simple and composite hypotheses, null hypotheses, alternative hypotheses, one-sided and two-sided hypotheses. The critical region and test statistic, type I error and type II error, level of significance. Power function of a test, most powerful test. The $p$-value (observed level of significance), Calculating $p$-values.
• Simple hypothesis versus simple alternative: Neyman-Pearson lemma (Statement only).

• Bivariate frequency Distribution: Bivariate data, Scatter diagram, Correlation, Linear Regression, principle of least squares and fitting of polynomials and exponential curves.

**Graphical Demonstration (Teaching Aid**) [5 classes]

• Graphical representation of data - how to load data, plot a graph viz. histograms (equal class intervals and unequal class intervals), frequency polygon, pie chart, ogives with graphical summaries of data.

• Measures of central tendency and measures of dispersion, moments, skewness and kurtosis.

• Karl Pearson correlation coefficient.

• Correlation coefficient for a bivariate frequency distribution.

• Lines of regression, angle between lines and estimated values of variables.

• Fitting of polynomials, exponential curves by method of least squares.

• Confidence interval for the parameters of a normal distribution (one sample and two sample problems).

** Preferably by free softwares (e.g. R/ Python / SageMath etc.) but can be taught through black board/white board / square sheet etc. in case of unavailability.**

References


Course Structure  DSE  SEC  Credit Distribution
Group Theory-II & Linear Algebra-II

| Semester : 5 |
| Core Course-12 |
| Paper Code (Theory): MTM-A-CC-5-12-TH |
| Paper Code (Tutorial): MTM-A-CC-5-12-TU |
| Credits : 5+1* = 6 |
| Full Marks : 65+15**+20*** = 100 |
| Number of classes required : 75 |
| *1 Credit for Tutorial |
| **15 Marks are reserved for Tutorial |
| ***20 Marks are reserved for Internal Assessment |
| & Attendance (10 marks for each) |

### Course Structure

#### Unit-1 : Group theory

- Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups.

- External direct product and its properties, the group of units modulo $n$ as an external direct product, internal direct product, converse of Lagrange's theorem for finite abelian group, Cauchy's theorem for finite abelian group, Fundamental theorem of finite abelian groups.

#### Unit-2 : Linear algebra

- Inner product spaces and norms, Gram-Schmidt orthonormalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator and its basic properties.

- Bilinear and quadratic forms, Diagonalisation of symmetric matrices, Second derivative test for critical point of a function of several variables, Hessian matrix, Sylvester's law of inertia. Index, signature.

- Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigenspaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms (Jordan & rational).

### References


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<tr>
<th>Course Structure</th>
<th>DSE</th>
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<th>Credit Distribution</th>
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</table>
Unit-1 : Metric space


- Convergent sequence. Cauchy sequence. Every convergent sequence is Cauchy and bounded, but the converse is not true. Completeness. Cantor’s intersection theorem. $\mathbb{R}$ is a complete metric space. $\mathbb{Q}$ is not complete.

- Continuous mappings, sequential criterion of continuity. Uniform continuity.

- Compactness, Sequential compactness, Heine-Borel theorem in $\mathbb{R}$. Finite intersection property, continuous functions on compact sets.

- Concept of connectedness and some examples of connected metric space, connected subsets of $\mathbb{R}, \mathbb{C}$.

- Contraction mappings, Banach Fixed point Theorem and its application to ordinary differential equations.

Unit-2 : Complex analysis

- Stereographic projection. Regions in the complex plane. Limits, limits involving the point at infinity. Continuity of functions of complex variable.

- Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, exponential function, logarithmic function, trigonometric functions, hyperbolic functions. Möbius transformation.


- Contours, complex integration along a contour and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem (statement only) and its consequences, Cauchy integral formula.

References


Numerical Methods

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<th>Course Structure</th>
<th>DSE</th>
<th>SEC</th>
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Semester : 6
Core Course-14
Paper Code(Theory): MTM-A-CC-6-14-TH

Number of classes required : 55

***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Unit-1
- Representation of real numbers, Machine Numbers - floating point and fixed point. Sources of Errors, Rounding of numbers, significant digits and Error Propagation in machine arithmetic operations. Numerical Algorithms - stability and convergence.

Unit-2
- Central Interpolation : Stirling’s and Bessel’s formulas. Different interpolation zones, Error estimation. Hermite interpolation.

Unit-3
- Numerical differentiation : Methods based on interpolations, methods based on finite differences.

Unit-4
- Numerical solution of system of nonlinear equations - Newton’s method.

Unit-5
- System of linear algebraic equations :
  Direct methods : Gaussian elimination and Gauss Jordan methods, Pivoting strategies.
- Matrix inversion : Gaussian elimination and LU decomposition method (Crout’s LU decomposition method) (operational counts).
- The algebraic eigen value problem : Power method.

Unit-6
References

List of practicals (using C/ C++/ FORTRAN 90)

1. Calculate the sum $\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{N}$

2. Enter 100 integers into an array and sort them in an ascending order.

3. Solution of transcendental and algebraic equations by
   - i) Bisection method
   - ii) Newton Raphson method (Simple root, multiple roots, complex roots).
   - iii) Secant method.
   - iv) Regula Falsi method.

4. Solution of system of linear equations
   - i) LU decomposition method
   - ii) Gaussian elimination method
   - iii) Gauss-Jacobi method
   - iv) Gauss-Seidel method

5. Interpolation
   - i) Lagrange Interpolation
   - ii) Newton’s forward, backward and divided difference interpolations

6. Numerical Integration
   - i) Trapezoidal Rule
   - ii) Simpson’s one third rule
   - iii) Weddle’s Rule
   - iv) Gauss Quadrature

7. Method of finding Eigenvalue by Power method (up to $4 \times 4$)

8. Fitting a Polynomial Function (up to third degree)

9. Solution of ordinary differential equations
   - i) Euler method
   - ii) Modified Euler method
   - iii) Runge Kutta method (order 4)
   - iv) The method of successive approximations (Picard)

Note: For any of the CAS (Computer aided software), Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.
Advanced Algebra

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<td>***20 Marks are reserved for Internal Assessment &amp; Attendance (10 marks for each)</td>
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Course Structure  DSE  SEC  Credit Distribution

Unit-1: Group Theory

- Group actions, stabilizers, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley’s theorem, Index theorem.
- Groups acting on themselves by conjugation, class equation and consequences, conjugacy in $S_n$, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of $A_n$ for $n \geq 5$, non-simplicity tests.

Unit-2: Ring Theory

- Principal ideal domain, principal ideal ring, prime element, irreducible element, greatest common divisor (gcd), least common multiple (lcm), expression of gcd, examples of a ring $R$ and a pair of elements $a, b \in R$ such that gcd$(a, b)$ does not exist, Euclidean domain, relation between Euclidean domain and principal ideal domain.
- Polynomial rings, division algorithm and consequences, factorization domain, unique factorization domain, irreducible and prime elements in a unique factorization domain, relation between principal ideal domain, unique factorization domain, factorization domain and integral domain, Eisenstein criterion and unique factorization in $\mathbb{Z}[x]$.
- Ring embedding and quotient field, regular rings and their examples, properties of regular ring, ideals in regular rings.

References

Bio Mathematics

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Course Structure | DSE | SEC | Credit Distribution

Unit-1


Unit-2


Unit-3


Graphical Demonstration (Teaching Aid) [using any software]

- Growth model (exponential case only).
- Decay model (exponential case only).
- Lake pollution model (with constant/seasonal flow and pollution concentration).
- Case of single cold pill and a course of cold pills.
- Limited growth of population (with and without harvesting).
- Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two prey one predator).
- Epidemic model of influenza (basic epidemic model, contagious for life,disease with carriers).
- Battle model (basic battle model, jungle warfare, long range weapons).
References

Industrial Mathematics

| Semester : 5 | Credits : 5+1*=6 |
| Discipline Specific Elective-A(1) | Full Marks : 65+15**+20***=100 |
| Number of classes required : 75 | |
| *1 Credit for Tutorial | |
| **15 Marks are reserved for Tutorial | |
| ***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each) | |

**Course Structure**  
**DSE**  
**SEC**  
**Credit Distribution**

**Unit-1**  
- Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

**Unit-2**  
- Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth’s interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

**Unit-3**  
- X-ray: Introduction, X-ray behavior and Beers Law (The fundamental question of image construction)  
Lines in the place

**Unit-4**  
- Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms).

**Unit-5**  
- Back Projection: Definition, properties and examples.

**Unit-6**  
- CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

**References**


Discrete Mathematics

Semesters: 5
Credits: 5+1*=6
Full Marks: 65+15**+20***=100
Discipline Specific Elective-DSE-B(1)
Paper Code(Theory):MTM-A-DSE-B-5-1-TH

Number of classes required: 75
*1 Credit for Tutorial
**15 Marks are reserved for Tutorial
***20 Marks are reserved for Internal Assessment
& Attendance (10 marks for each)

Course Structure DSE SEC Credit Distribution

Unit-1: Graph Theory [40 classes]
- Weighted graphs and Travelling salespersons Problem. Dijkstra’s algorithm to find shortest path.
- Definition of Trees and their elementary properties. Definition of Planar graphs, Kuratowski’s graphs.
- Partial Order relations and lattices, Chains and antichains. Pigeon hole Principle.

Unit-2: Number Theory [35 classes]
- Application of techniques of groups and rings to prove some theorems in number theory: Fermat’s Theorem, Euler’s Theorem, Willson’s Theorem, Chinese Remainder Theorem.
- The Arithmetic of $\mathbb{Z}_p$, $p$ a prime, pseudo prime and Carmichael Numbers, Fermat Numbers, Perfect Numbers, Mersenne Numbers.
- Primitive roots, the group of units $\mathbb{Z}_n^*$, the existence of primitive roots, applications of primitive roots, the algebraic structure of $\mathbb{Z}_n^*$.
- Quadratic residues and non quadratic residues, Legendre symbol, proof of the law of quadratic reciprocity, Jacobi symbols.
- Arithmetic functions, Multiplicative functions, definitions and examples.

References
[1] N. Deo; Graph Theory with Application to Engineering and Computer Science; Prentice Hall of India, New Delhi, 1990.


Linear Programming & Game Theory

Semesters : 5
Discipline Specific Elective- DSE-B(1)
Paper Code(Theory):MTM-A-DSE-B-5-1-TH

Credits : 5+1* = 6
Full Marks : 65+15**+20*** = 100

Number of classes required : 75
*1 Credit for Tutorial
**15 Marks are reserved for Tutorial
***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Course Structure  DSE  SEC  Credit Distribution

Unit-1 [15 classes]
- Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separating hyperplane. The collection of a feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions (the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

Unit-2 [20 classes]

Unit-3 [10 classes]
- Duality theory: The dual of dual is the primal. Relation between the objective values of dual and the primal problems. Relation between their optimal values. Complementary slackness, Duality and simplex method and their applications.

Unit-4 [30 classes]

References

Course Structure | DSE | SEC | Credit Distribution
---|---|---|---
Unit-1

- Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.

Unit-2

- Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Logic gates, switching circuits and applications of switching circuits.

Unit-3

- Introduction: Alphabets, strings, and languages. Finite automata and regular languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

Unit-4

- Context free grammars and pushdown automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non-deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties.

Unit-5

- Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

Unit-6

- Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem. Post correspondence problem, and undecidability problems about CFGs.

References


<table>
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<tr>
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<th>SEC</th>
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Differential Geometry

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Unit-1

- Tensor : Different transformation laws, Properties of tensors, Metric tensor, Riemannian space, Covariant Differentiation, Einstein space.

Unit-2


Unit-3


References

<table>
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<th>SEC</th>
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Mathematical Modelling

| Semesters : 6 | Credits : 5+1* = 6 |
| Discipline Specific Elective-DSE-A(2) | Full Marks : 65+15**+20***=100 |

*1 Credit for Tutorial

**15 Marks are reserved for Tutorial

***20 Marks are reserved for Internal Assessment

& Attendance (10 marks for each)

** Number of classes required : 75

Credit Distribution

Course Structure | DSE | SEC | Credit Distribution

Unit-1

- Power series solution of Bessel’s equation and Legendre’s equation, Laplace transform and inverse transform, application to initial value problem up to second order.

Unit-2

- Monte Carlo simulation modelling: simulating deterministic behavior (area under a curve, volume under a surface), generating random numbers: middle square method, linear congruence, queuing models: harbor system, morning rush hour, Overview of optimization modelling. Linear programming model: geometric solution algebraic solution, simplex method, sensitivity analysis

Graphical demonstration (Teaching aid **) [10 classes]

- Plotting of Legendre polynomial for n = 1 to 5 in the interval [0,1]. Verifying graphically that all the roots of $P_n(x)$ lie in the interval [0,1].

- Automatic computation of coefficients in the series solution near ordinary points.

- Plotting of the Bessel’s function of first kind of order 0 to 3.

- Automating the Frobenius Series Method.

- Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface.

- Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour).

- Programming of the Simplex method for 2/3 variables.

** Preferably by free softwares e.g. R / SageMath / Python etc.

References


Fluid Statics & Elementary Fluid Dynamics

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*1 Credit for Tutorial
**15 Marks are reserved for Tutorial
***20 Marks are reserved for Internal Assessment
& Attendance (10 marks for each)

Course Structure  DSE  SEC  Credit Distribution

Unit-1

- **Introduction and Fundamental Concepts:**
  Definition of Fluid, Distinction Between Solid and Fluid, Concept of Continuum, Fluid Properties: Density, Specific Weight, Specific Volume, Specific Gravity. Stress field [(Normal stress: $\sigma_n = \lim_{\delta A_n \to 0}(\delta F_n/\delta A_n)$ and Shear stress: $\tau_n = \lim_{\delta A_n \to 0}(\delta F_t/\delta A_n)$], Viscosity, Vapor pressure., Newtonian fluid, Non-Newtonian Fluids. Ideal Fluid, Compressibility, Distinction between an Incompressible and a Compressible Flow, Surface Tension of Liquids.

  Forces on Fluid Elements: Definition of Fluid Elements, Body Force, Surface Force, Normal Stress in a Stationary Fluid, Pascal's Law of Hydrostatics, Fundamental Equation of Fluid Statics: $\nabla p = \rho \vec{F}$, Fundamental Fluid Static Equations in Scalar Form: $\frac{\partial p}{\partial z} = \rho g$, Constant Density Solution.

Unit-2

- **Hydrostatics**

- **Gas**

Unit-3

- **Kinematics of Fluid:**

Unit-4

- **Conservation Equations:**
References


Course Structure  DSE  SEC  Credit Distribution
Course Structure

Point Set Topology

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<tr>
<td>***20 Marks are reserved for Internal Assessment &amp; Attendance (10 marks for each)</td>
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Unit-1

- Topological spaces, basis and subbasis for a topology, neighbourhoods of a point, interior points, limit points, derived set, boundary of a set, closed sets, closure and interior of a set, dense subsets, subspace topology, finite Product topology, Continuous functions, open maps, closed maps, homeomorphisms, topological invariants, metric topology, isometry and metric invariants.

Unit-2

- First countability, $T_1$ and $T_2$ separation axioms of topological spaces, convergence and cluster point of a sequence in topological spaces and some related concepts on first countable as well as on $T_2$ spaces. Heine’s continuity criterion.

Unit-3

- Connected spaces, connected sets in $\mathbb{R}$, components, Compact spaces, compactness and $T_2$, compact sets in $\mathbb{R}$, Heine-Borel Theorem for $\mathbb{R}^n$, real valued continuous function on connected and compact spaces, the concept of compactness in metric space, sequentially compactness of a metric space $X$ and the Bolzano-Weierstrass property of $X$ are equivalent.

References

Astronomy & Space Science

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<th>Credit Distribution</th>
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</table>

Number of classes required: 75

*1 Credit for Tutorial

**15 Marks are reserved for Tutorial

***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Unit-1

- Celestial Sphere, various Coordinate Systems, transformation formulae among various coordinate systems, formulae of spherical triangle: cosine formula, sine formula, four parts formula, analogous cosine formula, hour angle, sidereal day, sidereal time, equation of time. Exercises.

Unit-2

- Light and its properties, Optical, absorption, emission and continuous spectra, radio and Hubble Space Telescopes (HST), Photometry, Spectrometry, Spectrophotometry (definitions only), magnification, resolution, f/a ratio, refractors and reflectors. Exercises.

Unit-3


Unit-4

- Interstellar matter, elastic collisions and kinetic equilibrium, Jeans Mass for gravitational collapse, radiative process (statement only).

Unit-5


Unit-6

- Space agencies around the world – The history of space agencies – Indian space exploration – First missions – Remarkable achievements.

References

[12] International Space Olympiad: NASA.
  (Online tutorial, assignments and lecture notes).
Advanced Mechanics

<table>
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*1 Credit for Tutorial

**15 Marks are reserved for Tutorial

***20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Unit-1 [20 classes]

- Degrees of freedom, reactions due to constraints. D’ Alembert’s principle; Lagrange’s first kind equations; Generalized coordinates; Generalized forces; Lagrangian; Second kind Lagrange’s equations of motion; cyclic coordinates; velocity dependent potential; Principle of energy; Rayleigh’s dissipation function.

Unit-2 [20 classes]

- Action Integral; Hamilton’s principle; Lagrange’s equations by variational methods; Hamilton’s principle for non-holonomic system; Symmetry properties and conservation laws; Noether’s theorem. Canonically conjugate coordinates and momenta; Legendre transformation; Routhian approach; Hamiltonian.

Unit-3 [15 classes]

- Hamilton’s equations from variational principle; Poincare-Cartan integral invariant; Principle of stationary action; Fermat’s principle;

Unit-4 [20 classes]

- Canonical transformation; Generating function; Poisson Bracket; Equations of motion; Action-angle variables; Hamilton-Jacobi’s equation; Hamilton’s principal function; Hamilton’s characteristics function; Liouville’s theorem.

References


C Programming Language

<table>
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<th>DSE</th>
<th>SEC</th>
<th>Credit Distribution</th>
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</table>

- An overview of theoretical computers, history of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language and importance of C programming.

- Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.

- Operation and Expressions: Arithmetic operators, relational operators, logical operators.

- Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.

- Control Statements: While statement, do-while statement, for statement.

- Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.

- User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.

- Introduction to Library functions: stdio.h, math.h, string.h stdlib.h, time.h etc.

- Some hands on examples should be included.

References


Object Oriented Programming in C++

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<td>*20 Marks are reserved for Internal Assessment &amp; Attendance (10 marks for each)</td>
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</table>

Course Structure

Unit-1

- Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer.

Unit-2

- Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.

Unit-3

- Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.

List of hands on examples (using C++)

1. Calculate the sum $\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{N}$
2. Enter 100 integers into an array and sort them in an ascending order.
3. HCF and LCM of three positive integers.
4. Separate even and odd numbers from first N natural numbers.
5. Find all the prime numbers between 1 and N (N being a positive integer).
6. Find the binary representation of a decimal number (up to 3 digits).
7. Addition, subtraction, multiplication of two matrices (order up to $4 \times 4$).
8. Compute the value of the determinant of a square matrix (order up to $4 \times 4$).

References

Mathematical Logic

<table>
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<tbody>
<tr>
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Number of classes required : 50

*20 Marks are reserved for Internal Assessment 
& Attendance (10 marks for each)

Unit-1

[5 classes]

- Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.

- General Notions : Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Unit-2

[15 classes]

- Propositional Logic : Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Leidenbaum lemma, soundness and completeness theorems, algebraic semantics.

Unit-3

[10 classes]

- Predicate Logic : First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus, theorems and derivations, deduction theorem, equivalence theorem, replacement theorem, choice rule, Prenex normal form, soundness theorem, completeness theorem, compactness theorem, First Order Theory with equality, examples of First Order Theories (groups, rings, fields etc.).

References

Scientific computing with SageMath & R

<table>
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<td>Number of contact hours required : 50</td>
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*20 Marks are reserved for Internal Assessment & Attendance (10 marks for each)

Course Structure

- Introduction to SageMath and R, Installation Procedure, Use of SageMath & R as a Calculator, Numerical and symbolic computations using mathematical functions such as square root, trigonometric functions, logarithms, exponentiations etc.

- Graphical representations of few functions through plotting in a given interval, like plotting of polynomial functions, trigonometric functions, Plots of functions with asymptotes, superimposing multiple graphs in one plot like plotting a curve along with a tangent on that curve (if it exists), polar plotting of curves.

- SageMath & R commands for differentiation, higher order derivatives, plotting \( f(x) \) and \( f'(x) \) together, integrals, definite integrals etc.

- Introduction to Programming in SageMath & R, relational and logical operators, conditional statements, loops and nested loops, without using inbuilt functions write programs for average of integers, mean, median, mode, factorial, checking primes, checking next primes, finding all primes in an interval, finding gcd, lcm, finding convergence of a given sequence, etc.

- Use of inbuilt functions that deal with matrices, determinant, inverse of a given real square matrix (if it exists), solving a system of linear equations, finding roots of a given polynomial, solving differential equations.

- Some hands on examples should be included.

Note: The goal of this course is to introduce students to the fundamental commands and structure of SageMath & R. The course covers the basic syntax and semantics of SageMath & R, including basic data types, variables, control structures and functions or similar concepts, and visualization of results and processed data.

References

[1] An Introduction to R: W. N. Venables, D. M. Smith and the R Core Team (available online).

[2] https://www.datacamp.com/courses/free-introduction-to-r (Online tutorial on R)


Course Structure  DSE  SEC  Credit Distribution
University of Calcutta

Syllabus for three-year B.Sc. in Mathematics
(General)

Under

CBCS System

2018
1. Credit Distribution across Courses

<table>
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2. Course Structure : Semester-wise distribution of Courses

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* A student has to opt for 4 Skill Enhancement Courses in four Semesters (3rd to 6th) taking at least one Course from each discipline.
3. Choices for Skill Enhancement Courses in Mathematics (SEC)

<table>
<thead>
<tr>
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<tr>
<td>Skill Enhancement Course (Semester 3)-SEC A</td>
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<td>C Programming Language [13]</td>
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<td>Skill Enhancement Course (Semester 4)-SEC B</td>
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<td>Mathematical Logic [14]</td>
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<td>Skill Enhancement Course (Semester 5) -SEC A</td>
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<tr>
<td>Object Oriented Programming in C++ [15]</td>
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<tr>
<td>Skill Enhancement Course (Semester 6)-SEC B</td>
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<tr>
<td>Boolean Algebra [16]</td>
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# The number within the bracket [ ] refers to page number.

4. Choices for Discipline Specific Electives

DSE-A & B (Mathematics)

DSE-A: (Semesters 5/6) | DSE-B: (Semesters 5/6)
-----------------------|-----------------------
Particle Dynamics [17] | Advanced Calculus [19] |
Graph Theory [18]      | Mathematical Finance [20] |

# The number within the bracket [ ] refers to page number. A student has to opt for at least one of the subjects available under each category.
Unit-1 : Algebra-I (15 Marks)

- Complex Numbers: De Moivre’s Theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of $a^z$ ($a \neq 0$). Inverse circular and Hyperbolic functions.

- Polynomials: Fundamental Theorem of Algebra (Statement only). Polynomials with real coefficients, the $n$-th degree polynomial equation has exactly $n$ roots. Nature of roots of an equation (surd or complex roots occur in pairs). Statement of Descarte’s rule of signs and its applications.

- Statements of: (i) If a polynomial $f(x)$ has opposite signs for two real values $a$ and $b$ of $x$, the equation $f(x) = 0$ has odd number of real roots between $a$ and $b$. If $f(a)$ and $f(b)$ are of same sign, either no real root or an even number of roots lies between $a$ and $b$. (ii) Rolle’s Theorem and its direct applications. Relation between roots and coefficients, symmetric functions of roots, transformations of equations. Cardan’s method of solution of a cubic equation.

- Rank of a matrix: Determination of rank either by considering minors or by sweep-out process. Consistency and solution of a system of linear equations with not more than 3 variables by matrix method.

Unit-2 : Differential Calculus-I (25 Marks)

- Rational numbers, Geometrical representations, Irrational number, Real number represented as point on a line — Linear Continuum. Acquaintance with basic properties of real number (No deduction or proof is included).

- Real-valued functions defined on an interval, limit of a function (Cauchy’s definition). Algebra of limits. Continuity of a function at a point and in an interval. Acquaintance (on proof) with the important properties of continuous functions no closed intervals. Statement of existence of inverse function of a strictly monotone function and its continuity.


- Successive derivative - Leibnitz’s theorem and its application.

- Functions of two and three variables: their geometrical representations. Limit and Continuity (definitions only) for function of two variables. Partial derivatives. Knowledge and use of chain Rule. Exact differentials (emphasis on solving problems only). Functions of two variables - Successive partial Derivatives: Statement of Schwarz’s Theorem on Commutative property of mixed derivatives. Euler’s Theorem on homogeneous function of two and three variables.
Unit-3 : Differential Equation-I (15 Marks) [10 classes]

• Order, degree and solution of an ordinary differential equation (ODE) in presence of arbitrary constants. Formation of ODE.

• First order equations : (i) Exact equations and those reducible to such equation. (ii) Euler’s and Bernoulli’s equations (Linear). (iii) Clairaut’s Equations : General and Singular solutions.

• Second order linear equations : Second order linear differential equation with constant coefficients. Euler’s Homogeneous equations.

• Second order differential equation : (i) Method of variation of parameters, (ii) Method of undetermined coefficients.

Unit-4 : Coordinate Geometry (25 Marks) [20 classes]

• Transformations of Rectangular axes : Translation, Rotation and their combinations. Invariants.

• General equation of second degree in $x$ and $y$ : Reduction to canonical forms. Classification of conic.

• Pair of straight lines : Condition that the general equation of 2nd degree in $x$ and $y$ may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.

• Equations of pair of tangents from an external point, chord of contact, poles and polars in case of General conic : Particular cases for Parabola, Ellipse, Circle, Hyperbola.

• Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole. Equation of chord joining two points. Equations of tangent and normal.

• Sphere and its tangent plane. Right circular cone.
Unit-1 : Differential Calculus-II (20 Marks)  

- Sequence of real numbers: Definition of bounds of a sequence and monotone sequence. Limit of a sequence. Statements of limit theorems. Concept of convergence and divergence of monotone sequences-applications of the theorems, in particular, definition of $e$. Statement of Cauchy’s general principle of convergence and its application.


- Real-Valued functions defined on an interval: Statement of Rolle’s Theorem and its geometrical interpretation. Mean value theorems of Lagrange and Cauchy. Statements of Taylor’s and Maclaurin’s Theorems with Lagrange’s and Cauchy’s from of remainders. Taylor’s and Maclaurin’s Infinite series of functions like $e^x$, $\sin x$, $\cos x$, $(1 + x)^n$, $\log(1 + x)$ with restrictions wherever necessary.

- Indeterminate Forms: L’Hospital’s Rule: Statement and Problems only.

- Application of the principle of Maxima and Minima for a function of single variable in geometrical, physical and to other problems.

- Maxima and minima of functions of not more than three variables Lagrange’s Method of undetermined multiplier - Problems only.

Unit-2 : Differential Equation-II (15 Marks)  


Unit-3 : Vector Algebra (15 Marks)  

Unit-4: Discrete Mathematics (30 Marks) [25 classes]


• Congruences: Congruence relation on integers, Basic properties of this relation. Linear congruences, Chinese Remainder Theorem. System of Linear congruences. Definition of Congruence â€” to show it is an equivalence relation, to prove the following:
  (i) \( a \equiv b \pmod{m} \) implies
  \( (a + c) \equiv (b + c) \pmod{m} \)
  \( ac \equiv bc \pmod{m} \)
  \( a^n \equiv b^n \pmod{m} \), for any polynomial \( f(x) \) with integral coefficients \( f(a) \equiv f(b) \pmod{m} \) etc.
  Linear Congruence, to show how to solve these congruences, Chinese remainder theorem â€” Statement and proof and some applications. System of linear congruences, when solution exists â€” some applications.

• Application of Congruences: Divisibility tests. Check-digit and an ISBN, in Universal product Code, in major credit cards. Error detecting capability. Using Congruence, develop divisibility tests for integers based on their expansions with respect to different bases, if \( d \) divides \( (b - 1) \) then \( n = (a_k a_{k-1} a_1 b) \) is divisible by \( d \) if and only if the sum of the digits is divisible by \( d \) etc. Show that congruence can be used to schedule Round-Robin tournaments. Check digits for different identification numbers â€” International standard book number, universal product code etc. Theorem regarding error detecting capability.

• Congruence Classes: Congruence classes, addition and multiplication of congruence classes. Fermat’s little theorem. Euler’s theorem. Wilson’s theorem. Some simple applications.

• Boolean algebra: Boolean Algebra, Boolean functions, Logic gates, Minimization of circuits.

Course Structure  SEC  DSE  Credit Distribution
Mathematics - CC3/GE3

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<th>Course Structure</th>
<th>SEC</th>
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<td>***20 Mark is reserved for Internal Assessment &amp; Attendance of 10 mark each</td>
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Unit-1 : Integral Calculus (20 Marks) [10 classes]
- Evaluation of definite integrals.
- Integration as the limit of a sum (with equally spaced as well as unequal intervals).
- Reduction formulae of \[ \int \sin^n x \cos^m x \, dx, \int \sin^m x \cos^n x \, dx, \int \tan^n x \, dx \] and associated problems (\( m \) and \( n \) are non-negative integers).
- Definition of Improper Integrals : Statements of (i) \( \mu \)-test (ii) Comparison test (Limit from excluded) - Simple problems only. Use of Beta and Gamma functions (convergence and important relations being assumed).
- Working knowledge of double integral.
- Applications : Rectification, Quadrature, volume and surface areas of solids formed by revolution of plane curve and areas problems only.

Unit-2 : Numerical Methods (30 Marks) [25 classes]
- Approximate numbers, Significant figures, Rounding off numbers. Error : Absolute, Relative and percentage.
- Operators - \( \Delta, \nabla \) and \( E \) (Definitions and some relations among them).
- Interpolation : The problem of interpolation Equispaced arguments Difference Tables, Deduction of Newton’s Forward Interpolation Formula, remainder term (expression only). Newton’s Backward interpolation Formula (Statement only) with remainder term. Unequally- spaced arguments Lagrange’s Interpolation Formula (Statement only). Numerical problems on Interpolation with both equally and unequally spaced arguments.
- Numerical Integration : Trapezoidal and Simpson’s 1 \( \frac{1}{3} \)rd formula (statement only). Problems on Numerical Integration.
- Solution of Numerical Equation : To find a real root of an algebraic or transcendental equation. Location of root (tabular method), Bisection method, Newton-Raphson method with geometrical significance, Numerical Problems. (Note : Emphasis should be given on problems)

Unit-3 : Linear Programming (30 Marks) [25 classes]

The set of all feasible solutions of an L.P.P. is a convex set. The objective function of an L.P.P. assumes its optimal value at an extreme print of the convex set of feasible solutions, A.B.F.S. to an L.P.P. corresponds to an extreme point of the convex set of feasible solutions.

Fundamental Theorem of L.P.P. (Statement only) Reduction of a feasible solution to a B.F.S. Standard form of an L.P.P. Solution by graphical method (for two variables), by simplex method and method of penalty. Concept of Duality. Duality Theory. The dual of the dual is the primal. Relation between the objective values of dual and the primal problems. Dual problems with at most one unrestricted variable, one constraint of equality. Transportation and Assignment problem and their optimal solutions.
Unit-1 : Algebra-II (20 Marks) [10 classes]

- Introduction of Group Theory: Definition and examples taken from various branches (example from number system, roots of Unity, $2 \times 2$ real matrices, non singular real matrices of a fixed order). Elementary properties using definition of Group. Definition and examples of sub-group - Statement of necessary and sufficient condition and its applications.

- Definitions and examples of (i) Ring, (ii) Field, (iii) Sub-ring, (iv) Sub-field.

- Concept of Vector space over a Field: Examples, Concepts of Linear combinations, Linear dependence and independence of a finite number of vectors, Sub-space, Concepts of generators and basis of a finite-dimensional vector space. Problems on formation of basis of a vector space (No proof required).

- Real Quadratic Form involving not more than three variables (problems only).

- Characteristic equation of square matrix of order not more than three determination of Eigen Values and Eigen Vectors (problems only). Statement and illustration of Cayley-Hamilton Theorem.

Unit-2 : Computer Science & Programming (30 Marks) [25 classes]


- Positional Number System. Binary to Decimal and Decimal to Binary. Other systems. Binary Arithmetic. Octal, Hexadecimal, etc. Storing of data in a Computer - BIT, BYTE, WORD etc. Coding of a data-ASCII, etc.

- Programming Language: Machine language, Assembly language and High level language, Compiler and interpreter. Object Programme and source Programme. Ideas about some HLL– e.g. BASIC, FORTRAN, C, C++, COBOL, PASCAL, etc.

- Algorithms and Flow Charts– their utilities and important features, Ideas about the complexities of an algorithm. Application in simple problems. FORTRAN 77/90: Introduction, Data Type– Keywords, Constants and Variables - Integer, Real, Complex, Logical, character, subscripted variables, Fortran Expressions.

Unit-3 : Probability & Statistics (30 Marks) [25 classes]

• Theoretical Probability Distribution Discrete and Continuous (p.m.f., p.d.f.) Binomial, Poisson and Normal distributions and their properties.


• Bivariate Frequency Distribution. Scatter Diagram, Co-relation co-efficient Definition and properties. Regression lines.
Unit-1
[30 classes]

- An overview of theoretical computers, history of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language and importance of C programming.
- Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.
- Operation and Expressions: Arithmetic operators, relational operators, logical operators.
- Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.
- Control Statements: While statement, do-while statement, for statement.
- Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.
- User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.
- Introduction to Library functions: stdio.h, math.h, string.h stdlib.h, time.h etc.

References

Unit-1
[5 classes]
• Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.
• General Notions: Formal language, object and meta language, general definition of a Formal Theory/Formal Logic.

Unit-2
[15 classes]
• Propositional Logic: Formal theory for propositional calculus, derivation, proof, theorem, deduction theorem, conjunctive and disjunctive normal forms, semantics, truth tables, tautology, adequate set of connectives, applications to switching circuits, logical consequence, consistency, maximal consistency, Leidenbaum lemma, soundness and completeness theorems, algebraic semantics.

Unit-3
[10 classes]
• Predicate Logic: First order language, symbolizing ordinary sentences into first order formulae, free and bound variables, interpretation and satisfiability, models, logical validity, formal theory for predicate calculus, theorems and derivations, deduction theorem, equivalence theorem, replacement theorem, choice rule, Prenex normal form, soundness theorem, completeness theorem, compactness theorem, First Order Theory with equality, examples of First Order Theories (groups, rings, fields etc.).

References
Object Oriented Programming in C++

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*Minimum number of classes required : 30
*20 Mark is reserved for Internal Assessment
& Attendance of 10 mark each

Course Structure | DSE | SEC | Credit Distribution

Unit-1 [10 classes]
- Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer.

Unit-2 [10 classes]
- Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.

Unit-3 [10 classes]
- Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.

References

Boolean Algebra

| Semester : 6 |
| Skill Enhancement Course- SEC B |
| Paper Code (Theory) : MTM-G-SEC-B-TH |
| Credits : 2 |
| Full Marks : 100 (= 80+20*) |

Minimum number of classes required : 30
*20 Mark is reserved for Internal Assessment & Attendance of 10 mark each

Course Structure | DSE | SEC | Credit Distribution

[30 classes]

• Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms. Definition, examples and properties of modular and distributive lattices, Boolean algebras.

• Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and minimization of switching circuits using Boolean algebra.

References


Particle Dynamics

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Minimum number of classes required : 60

*1 Credit for Tutorial

**15 Mark is reserved for Tutorial

***20 Mark is reserved for Internal Assessment

& Attendance of 10 mark each

Course Structure | DSE | SEC | Credit Distribution

[60 classes]

- Velocity and Acceleration of a particle. Expressions for velocity and acceleration in rectangular Cartesian and polar co-ordinates for a particle moving in a plane. Tangential and normal components of velocity and acceleration of a particle moving along a plane curve.

- Concept of Force: Statement and explanation of Newton’s laws of motion. Work, power and energy. Principles of conservation of energy and momentum. Motion under impulsive forces. Equations of motion of a particle (i) moving in a straight line, (ii) moving in a plane.

- Study of motion of a particle in a straight line under (i) constant forces, (ii) variable forces (S.H.M., Inverse square law, Damped oscillation, Forced and Damped oscillation, Motion in an elastic string). Equations of Energy. Conservative forces.

- Motion in two dimensions: Projectiles in vacuum and in a medium with resistance varying linearly as velocity. Motion under forces varying as distance from a fixed point.

- Central orbit. Kepler’s laws of motion. Motion under inverse square law.

References


[2] A.S. Ramsey; Dynamics, Part-II; ELBS.
Graph Theory

Semesters: 5/6
Discipline Specific Elective-DSE-A

Credits: 5+1*=6
Full Marks: 65+15**+20***=100

Minimum number of classes required: 60
*1 Credit for Tutorial
**15 Mark is reserved for Tutorial
***20 Mark is reserved for Internal Assessment
& Attendance of 10 mark each

Course Structure  DSE  SEC  Credit Distribution

Unit-1

[60 classes]

- Definition, examples and basic properties of graphs, pseudographs, complete graphs, bi-partite graphs, isomorphism of graphs
- Paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman’s problem, shortest path, Dijkstra’s algorithm, Floyd-Warshall algorithm.
- Definition of Trees and their elementary properties. Definition of Planar graphs, Kuratowski’s graphs.

References

• Concept of Point-wise and Uniform convergence of sequence of functions and series of functions with special reference of Power Series. Statement of Weierstrass M-Test for Uniform convergence of sequence of functions and of series of functions. Simple applications. Statement of important properties like boundedness, continuity, differentiability and integrability of the limit function of uniformly convergent sequence of functions and of the sum function of uniformly convergent series of functions. Determination of Radius of convergence of Power Series. Statement of properties of continuity of sum function power series. Term by term integration and Term by term differentiation of Power Series. Statements of Abel’s Theorems on Power Series. Convergence of Power Series. Expansions of elementary functions such as $e^x$, $\sin x$, $\log(1+x)$, $(1+x)^n$. Simple problems.

• Periodic Fourier series on $(-\pi, \pi)$: Periodic function. Determination of Fourier coefficients. Statement of Dirichlet’s conditions of convergence and statement of the theorem on convergence of Fourier Sine and Cosine series.


References

[1] David Widder; Advance Calculus; Prentice Hall.
Mathematical Finance

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<td>Full Marks : 65+15**+20***=100</td>
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Minimum number of classes required : 60

*1 Credit for Tutorial
**15 Mark is reserved for Tutorial
***20 Mark is reserved for Internal Assessment
& Attendance of 10 mark each

Course Structure

DSE

SEC

Credit Distribution

Unit-1

[60 classes]

• Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods)

• Comparison of NPV and IRR. Bonds, bond prices and yields. Floating-rate bonds, immunization. Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints).

References