# UNIVERSITY OF CALCUTTA

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**Ref.No : CUS/ 57 /18**
**Dated the 01st February, 2018**

**To**
**The Principals/T.I.C.**
**of all the Undergraduate Colleges**
**offering B.Sc. (Honours) in Mathematics**
**affiliated to the University of Calcutta**

Sir/Madam,

The undersigned is to inform you that the proposed **revised semesterised draft Syllabus for Mathematics (Honours)** Courses of Studies under **CBCS has been uploaded in the Calcutta University website (www.caluniv.ac.in).**

The said syllabus has been prepared by the **U.G. Board of Studies in Mathematics, C.U.**, suppose to be implemented from the academic session 2018-2019

You are requested kindly to go through it and send your feedback within 15th February, 2018.

In this regard you may send your observation/ suggestion to the **Department of U.G. Councils, C.U.** or through email (u.g.councilsc.u@gmail.com), and you also may contact **Prof. Tanuka Chattopadhyay,** Department of Mathematics, C.U. through e-mail **(tanuka2008@gmail.com ).**

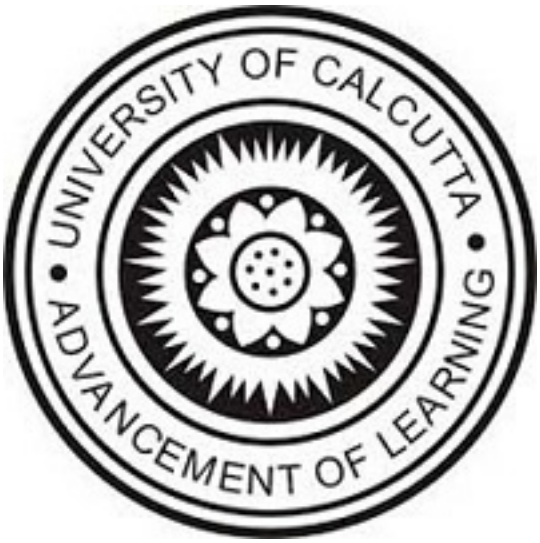
Your cooperation in this regard will be highly appreciated. Kindly treat the matter as urgent.

Thanking you,

Yours faithfully,

01/02/18

**Secretary**




# University of Calcutta

## Syllabus for three-year B.Sc. in Mathematics

## (Honours)

***under***

**CBCS System**

**2018**

# 1. Credit Distribution across Courses

| Course Type | Total Papers | Credits | | |
|---|---|---|---|---|
| | | Theory + Tutorial | Theory + Practical | Total |
| Core Courses | 14 | $13 \times 5 = 65$<br>$13 \times 1 = 13$ | $1 \times 4 = 4$<br>$1 \times 2 = 2$ | 84 |
| Discipline Specific Electives | 4 | $4 \times 5 = 20$<br>$4 \times 1 = 4$ | — | 24 |
| Generic Electives | 4 | $4 \times 6 = 24$ | — | 24 |
| Ability Enhancement Language Courses | 2 | $2 \times 2 = 4$ | — | 4 |
| Skill Enhancement Courses | 2 | $2 \times 2 = 4$ | — | 4 |
| **Totals** | 26 | 134 | 6 | 140 |

# 2. Course Structure : Semester-wise distribution of Courses

| Semester | Course Name | Course Detail | Credits | Page No. |
|---|---|---|---|---|
| I | Ability Enhancement Compulsory Course-I | English communication / Environmental Science | 2 | |
| | Core Course-I | Calculus, Geometry & Vector Analysis | 6 | 4 |
| | Core Course-II | Algebra | 6 | 6 |
| | Generic Elective-1 | See GE * | 6 | 54 |
| | | **Total** | **20** | |
| II | Ability Enhancement Compulsory Course-II | English communication / Environmental Science | 2 | |
| | Core Course-III | Real Analysis | 6 | 7 |
| | Core Course-IV | Group Theory-I | 6 | 9 |
| | Generic Elective-2 | See GE * | 6 | 54 |
| | | **Total** | **20** | |
| III | Core Course-V | Theory of Real Functions | 6 | 10 |
| | Core Course-VI | Ring Theory & Linear Algebra-I | 6 | 12 |
| | Core Course-VII | ODE & Multivariate Calculus-I | 6 | 13 |
| | Skill Enhancement Course-1 | See SEC | 2 | 3 |
| | Generic Elective-3 | See GE * | 6 | 54 |
| | | **Total** | **26** | |
| IV | Core Course-VIII | Riemann Integration & Series of Functions | 6 | 15 |
| | Core Course-IX | PDE & Multivariate Calculus-II | 6 | 17 |
| | Core Course-X | Mechanics | 6 | 19 |
| | Skill Enhancement Course-2 | See SEC | 2 | 3 |
| | Generic Elective-4 | See GE * | 6 | 54 |
| | | **Total** | **26** | |
| V | Core Course-XI | Probability & Statistics | 6 | 21 |
| | Core Course-XII | Group Theory-II & Linear Algebra-II | 6 | 23 |
| | Discipline Specific Elective-1 | See DSE | 6 | 3 |
| | Discipline Specific Elective-2 | See DSE | 6 | 3 |
| | | **Total** | **24** | |
| VI | Core Course-XIII | Metric Space & Complex Analysis | 6 | 24 |
| | Core Course-XIV | Numerical Methods | 4 | 26 |
| | Core Course-XIV Practical | Numerical Methods Lab | 2 | 28 |
| | Discipline Specific Elective-3 | See DSE | 6 | 3 |
| | Discipline Specific Elective-4 | See DSE | 6 | 3 |
| | | **Total** | **24** | |
| | | **Grand Total** | **140** | |

*These courses are to be taken by the students of **other discipline**.

Course Structure | Credit Distribution | DSE | SEC | GE

# 3. Choices for Discipline Specific Electives (DSE)

| DSE-1 (for Semester V) | DSE-2 (for Semester V) | DSE-3 (for Semester VI) | DSE-4 (for Semester VI) |
|---|---|---|---|
| Rigid Dynamics [29] | Discrete Mathematics [33] | Linear Programming [38] | Point Set Topology [43] |
| Advanced Algebra [30] | Financial Mathematics [35] | Boolean Algebra & Automata Theory [40] | Astronomy [44] |
| Bio Mathematics [31] | Fluid Statics & Elementary Fluid Dynamics [36] | Differential Geometry [42] | Advanced Mechanics [46] |

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

Course Structure | Credit Distribution | SEC

# 4. Choices for Skill Enhancement Courses (SEC)

| SEC-1 (for Semester III) | SEC-2 (for Semester IV) |
|---|---|
| C Programming Language [48] | Mathematical Logic [50] |
| Object Oriented Programming in C++ [49] | Scientific computing with SageMath/Mathematica [51] |
| | Introduction to MATLAB [52] |

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

Course Structure | Credit Distribution | DSE

# Calculus, Geometry & Vector Analysis

| | |
|---|---|
| Semester : I<br>Core Course-I<br>Paper Code: MH(CC1)101 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Calculus [25 classes]

- 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 $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \tan^n x dx$, $\int \sec^n x dx$, $\int (\log x)^n dx$, $\int \sin^n x \sin mx dx$, $\int \sin^n x \cos^m x dx$. 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 [30 classes]

- Rotation of axes and second degree equations, classification of conics using the discriminant, tangent and normal, polar equations of conics.
- Equation of Plane : General form, Intercept and Normal forms. The sides of a plane. Signed distance of a point from a plane. Equation of a plane passing through the intersection of two planes. Angle between two intersecting planes. Parallelism and perpendicularity of two planes.
- Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid.

## Unit-3 : Vector Analysis [15 classes]

- 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) [5 classes]

- 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.

## References


[1] G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

[2] M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.

[3] H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.

[4] R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.

[5] T. Apostol, Calculus, Volumes I and II.

[6] S. Goldberg, Calculus and mathematical analysis.

[7] Marsden, J., and Tromba, Vector Calculus, McGraw Hill.

[8] M.R. Speigel, SchaumÃââs outline of Vector Analysis.

[9] S. L. Loney, Co-ordinate Geometry.

[10] Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions.



Course Structure | DSE | SEC | Credit Distribution

# Algebra

| | |
|---|---|
| Semester : I<br>Core Course-II<br>Paper Code: MH(CC2)102 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## 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]

- Relation : equivalence relation, equivalence classes & partition, partial order relation, poset, linear order relation.
- 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

[1] Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.

[2] Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.

[3] David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

[4] K. Hoffman, R. Kunze, Linear algebra.

[5] W.S. Burnstine and A.W. Panton, Theory of equations.

Course Structure | DSE | SEC | Credit Distribution

# Real Analysis

| | |
|---|---|
| Semester : II<br>Core Course-III<br>Paper Code: MH(CC3)201 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment & Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[30 classes]

- 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 $\mathbb{R}$.
- 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 $\mathbb{R}$.

## Unit-2

[30 classes]

- Real sequence. Bounded sequence. Convergence and non-convergence. Examples. Boundedness of convergent sequence. Uniqueness of limit. Algebra of limits.
- 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 : $\left\{n^{\frac{1}{n}}\right\}_n$, $\{x^n\}_n$, $\left\{x^{\frac{1}{n}}\right\}_n$, $\{x_n\}_n$ with $\frac{x_{n+1}}{x_n} \to l$ and $|l| < 1$, $\left\{\left(1+\frac{1}{n}\right)^n\right\}_n$, $\left\{1+\frac{1}{1!}+\frac{1}{2!}+\cdots+\frac{1}{n!}\right\}_n$, $\{a^{x_n}\}_n\,(a>0)$. Cauchy's first and second limit theorems.
- Subsequence. Subsequential limits, $\limsup$ as the L.U.B. and $\liminf$ 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 $\limsup x_n = \inf_n \sup\{x_n, x_{n+1}, \ldots,\}$ and $\liminf x_n = \sup_n \inf\{x_n, x_{n+1}, \ldots,\}$ [Equivalence between these definitions is assumed]. A bounded sequence $\{x_n\}$ is convergent if and only if $\limsup x_n = \liminf x_n$. Every sequence has a monotone subsequence. Bolzano-Weirstrass theorem for sequence. Cauchy's convergence criterion. Cauchy sequence.

## Unit-3

[10 classes]

- 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. Alternating series, Leibniz test. Absolute and conditional convergence.

## Graphical Demonstration (Teaching aid)

[5 classes]

- Plotting of recursive sequences.
- 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.

## References


[1] R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

[2] Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.

[3] Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis,Prentice Hall, 2001.

[4] S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House

[6] Courant and John, Introduction to Calculus and Analysis, Vol I, Springer

[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill

[8] C. C. Pugh, Real Mathematical Analysis, Springer, 2002.

[9] Terence Tao, Analysis I, Hindustan Book Agency, 2006.

[10] S. Goldberg, Calculus and mathematical analysis.

[11] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.



Course Structure | DSE | SEC | Credit Distribution

# Group Theory-I

| | |
|---|---|
| Semester : II<br>Core Course-IV<br>Paper Code: MH(CC4)202 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Mark are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[30 classes]

- 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

[25 classes]

- 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

[20 classes]

- Normal subgroup and its properties. Quotient group. Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

## References

[1] John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

[2] M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

[3] Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.

[4] Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.

[5] I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

[6] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

Course Structure | DSE | SEC | Credit Distribution

# Theory of Real Functions

| | |
|---|---|
| Semester : III<br>Core Course-V<br>Paper Code: MH(CC5)301 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment & Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Limit & Continuity of functions [40 classes]

- Limits of functions ($\epsilon - \delta$ approach), sequential criterion for limits. Limit theorems, one sided limits. Infinite limits and limits at infinity. Important limits like $\frac{\sin x}{x}$, $\frac{\log(1+x)}{x}$, $\frac{a^x-1}{x}$ $(a > 0)$ as $x \longrightarrow 0$.
- 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 atmost 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 [35 classes]

- 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


[1] R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

[2] Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.

[3] Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis,Prentice Hall, 2001.

[4] S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House

[6] Courant and John, Introduction to Calculus and Analysis, Vol I, Springer

[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill

[8] C. C. Pugh, Real Mathematical Analysis, Springer, 2002.

[9] Terence Tao, Analysis I, Hindustan Book Agency, 2006.

[10] S. Goldberg, Calculus and mathematical analysis.

[11] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.



Course Structure | DSE | SEC | Credit Distribution

# Ring Theory & Linear Algebra-I

| | |
|---|---|
| Semester : III<br>Core Course-VI<br>Paper Code: MH(CC6)302 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Ring theory [35 classes]

- 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 [40 classes]

- 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.
- Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, change of coordinate matrix. Algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms. Eigen values, eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix,

## References


[1] John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

[2] M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

[3] Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.

[4] Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.

[5] S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.

[6] Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.

[7] S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.

[8] Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.

[9] D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.

[10] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.


Course Structure | DSE | SEC | Credit Distribution

# Ordinary Differential Equation & Multivariate Calculus-I

| | |
|---|---|
| Semester : III<br>Core Course-VII<br>Paper Code: MH(CC7)303 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Ordinary differential equation [40 classes]

- 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.
- Linear differential equations of second order, Wronskian : its properties and applications, Euler equation, method of undetermined coefficients, method of variation of parameters.
- 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.

## Unit-2 : Multivariate Calculus-I [35 classes]

- Functions of several variables, 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

[2] H.T. H.Piaggio, Elementary Treaties on Differential Equations and their applications, C.B.S Publisher & Distributors, Delhi,1985.

[3] G.F.Simmons, Differential Equations, Tata Mc Graw Hill

[4] S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

[5] Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill

[6] M.R. Speigel, Schaum's outline of Laplace Transform

[7] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.

Course Structure | DSE | SEC | Credit Distribution

# Riemann Integration & Series of Functions

| | |
|---|---|
| Semester : IV<br>Core Course-VIII<br>Paper Code: MH(CC8)401 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Riemann integration [35 classes]

- Partition and refinement of partition of a closed and bounded interval. Upper Darboux sum $U(P, f)$ and lower Darboux sum $L(P, f)$ and associated results. Upper integral and lower integral. Darboux's theorem. Darboux's definition of integration over a closed and bounded interval. Riemann's definition of integrability. Equivalence with Darboux definition of integrability (statement only). Necessary and sufficient condition for Riemann integrability.
- 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.
- Integrability 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 indefinite 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 [10 classes]

- 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 $\Big[\Gamma(n)\Gamma(1-n) = \frac{\pi}{\sin n\pi}, 0 < n < 1$, to be assumed$\Big]$. 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 [30 classes]

- Sequence of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weirstrass' M-test. Boundedness, continuity, integrability and differentiability of the limit function of a sequence of functions in case of uniform convergence.
- Series of functions defined on a set, Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Weierstrass' M-test. Passage to the limit term by term. Boundedness, continuity, integrability, differentiability of a series of functions in case of uniform convergence.

- Power series : Fundamental theorem of power series. Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Properties of sum function. Differentiation and integration of power series. Abel's limit theorems. Uniqueness of power series having sum function.
- 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


[1] R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

[2] Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.

[3] Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis,Prentice Hall, 2001.

[4] S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House

[6] Courant and John, Introduction to Calculus and Analysis, Vol I, Springer

[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill

[8] C. C. Pugh, Real Mathematical Analysis, Springer, 2002.

[9] Terence Tao, Analysis I, Hindustan Book Agency, 2006.

[10] S. Goldberg, Calculus and mathematical analysis.

[11] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.



Course Structure | DSE | SEC | Credit Distribution

# Partial differential equation & Multivariate Calculus-II

| | |
|---|---|
| Semester : IV<br>Core Course-IX<br>Paper Code: MH(CC9)402 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Partial differential equation [40 classes]

- 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.
- The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of finite and infinite string. Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end. Equations with non-homogeneous boundary conditions. Non-homogeneous wave equation. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem.

## Unit-2 : Multivariate Calculus-II [35 classes]

- Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals. Differentiation under the integral sign, Leibniz's rule.
- 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

[1] G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

[2] M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

[3] E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), 2005.

[4] James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001

[5] T. Apostol, Mathematical Analysis, Narosa Publishing House.

[6] Courant and John, Introduction to Calculus and Analysis, Vol II, Springer

[7] W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.

[8] Horst R. Beyer, Calculus and Analysis, Wiley, 2010.

Course Structure | DSE | SEC | Credit Distribution

# Mechanics

| | |
|---|---|
| Semester : IV<br>Core Course-X<br>Paper Code: MH(CC10)403 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[15 classes]

- **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, Poinsot'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

[10 classes]

- **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

[20 classes]

- **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

[20 classes]

- **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

[10 classes]

- **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


[1] Gregory R.D., Classical mechanics, Cambridge UP

[2] K. R. Symon, Mechanics, Addison Wesley

[3] Mary Lunn; A First Course in Mechanics, OUP

[4] J. L. Synge, B. A. Griffith, Principles of Mechanics, Mcgraw Hill

[5] T. W. B. Kibble, F. H. Berkshire, Classical Mechanics, Imperial College Press

[6] D. T. Greenwood, Principle of Dynamics, PHI

[7] Chorlton, F., Textbook of Dynamics.

[8] D. Kleppner & R. Kolenkow, Introduction to Mechanics, Tata Mcgraw Hill

[9] A. P. French, Newtonian Mechanics, Viva Books

[10] Timoshenko and Young, Engineering Mechanics, Mcgraw Hill

[11] D. Chernilevski, E. Lavrova, V. Romanov, Mechanics for Engineers, MIR Publishers

[12] I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, (4th Ed.), Dorling Kindersley(India) Pvt. Ltd. (Pearson Education), Delhi, 2009.

[13] R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

[14] Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press .

[15] Loney, S. L., An Elementary Treatise on Statics

[16] Verma, R. S., A Textbook on Statics, Pothishala, 1962

[17] Ramsey, A. S., Dynamics (Part I & II).



Course Structure | DSE | SEC | Credit Distribution

# Probability & Statistics

| | |
|---|---|
| Semester : V<br>Core Course-XI<br>Paper Code: MH(CC11)501 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[20 classes]

- 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

[15 classes]

- 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

[5 classes]

- 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

[15 classes]

- Sampling and Sampling Distributions : Populations and Samples, Random Sample, distribution of the sample, Simple random sampling with and without replacement. Sample characteristics.
- Sampling Distributions : Statictic, Sample moments. Sample variance, Sampling from the normal distributions, Chi-square, $t$ and $F$-distributions, sampling distribution of $\overline{X}$, $S^2$, $\frac{\sqrt{n}}{S}(\overline{X}-\mu)$
- Estimation of parameters : Point estimation and interval estimation. Mean-squared error. Properties of good estimators - unbiasedness, consistency, sufficiency, Minimum-Variance Unbiased Estimator (MVUE).
- Method of Maximum likelihood : likelihood function, ML estimators for discrete and continuous models.

## Unit-5

[15 classes]

- 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).
- Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
  (i) $Z$-test for population (Normal) mean, equality of two population (Normal) means.
  (ii) $Z$-test for single proportion, equality of two proportions.
  (iii) $t$-test for population (Normal) mean, equality of two population (Normal) means.
  (iv) $f$-test for equality of two variances.
  (v) idea of calculating $p$-values and its interpretation.

## References


[1] William Feller, An introduction to Probability Theory and its Application, Volume 1, 3e.

[2] Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.

[3] Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.

[4] Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.

[5] Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007

[6] A.M. Goon, M.K.Gupta and B.Dasgupta, Fundamental of Statistics, Vol 1 & Vol 2, World Press.

[7] A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers .



Course Structure | DSE | SEC | Credit Distribution

# Group Theory-II & Linear Algebra-II

| | |
|---|---|
| Semester : V<br>Core Course-XII<br>Paper Code: MH(CC12)502 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Group theory [35 classes]

- 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 [40 classes]

- 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


[1] John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

[2] M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

[3] Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.

[4] Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.

[5] I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

[6] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

[7] Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.

[8] S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.

[9] Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.

[10] S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.

[11] Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.

[12] D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.


Course Structure | DSE | SEC | Credit Distribution

# Metric Space & Complex Analysis

| | |
|---|---|
| Semester : VI<br>Core Course-XIII<br>Paper Code: MH(CC13)601 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Metric space [40 classes]

- Definition and examples of metric spaces. Open ball. Open set. Closed set as complement of open set. Interior point and interior of a set. Limit point and closure of a set. Boundary point and boundary of a set. Properties of interior, closure and boundary. Bounded set and diameter of a set. Distance between two sets. Subspace of a 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 [35 classes]

- 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.
- Power series : Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Analytic functions represented by power series. Uniqueness of power series.
- 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

[1] Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.

[2] S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.

[3] P. K. Jain and K. Ahmad, Metric Spaces, Narosa Publishing House.

[4] G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

[5] James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw Ãâåœ Hill International Edition, 2009.

[6] Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

[7] S. Ponnusamy, Foundations of complex analysis.

[8] E. M. Stein and R. Shakrachi, Complex Analysis, Princeton University Press.

Course Structure | DSE | SEC | Credit Distribution

# Numerical Methods

| | |
|---|---|
| Semester : VI<br>Core Course-XIV<br>Paper Code: MH(CC14)602 | Credits : 4<br>Full Marks : 50+20**=70 |
| *Number of classes required* : 55 | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[5 classes]

- 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

[15 classes]

- Approximation : Classes of approximating functions, Types of approximations- polynomial approximation, The Weierstrass polynomial approximation theorem (statement only).
- Interpolation : Lagrange and Newton's methods. Error bounds. Finite difference operators. Newton (Gregory) forward and backward difference interpolation.
- Central Interpolation : Stirling's and Bessel's formulas. Different interpolation zones, Error estimation. Hermite interpolation.

## Unit-3

[10 classes]

- Numerical differentiation : Methods based on interpolations, methods based on finite differences.
- Numerical Integration : Newton Cotes formula, Trapezoidal rule, Simpson's $\frac{1}{3}$-rd rule, Simpson's $\frac{3}{8}$-th rule, Weddle's rule, Boole's Rule, midpoint rule. Composite trapezoidal rule, composite Simpson's $\frac{1}{3}$-rd rule, composite Weddle's rule. Gaussian quadrature formula.

## Unit-4

[10 classes]

- Transcendental and polynomial equations : Bisection method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Condition of convergence (if any), Order of convergence, Rate of convergence of these methods. Modified Newton-Raphson method for multiple roots, Complex roots of an algebraic equation by Newton-Raphson method.

  Numerical solution of system of nonlinear equations - Newton's method.

## Unit-5

[10 classes]

- System of linear algebraic equations :
  Direct methods : Gaussian elimination and Gauss Jordan methods, Pivoting strategies.
- Iterative methods : Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition method (Crout's LU decomposition method).
- Matrix inversion : Gaussian elimination and LU decomposition method (Crout's LU decomposition method) (operational counts).
- The algebraic eigen value problem : Power method.

## Unit-6

[5 classes]

- Ordinary differential equations : Single-step difference equation methods- error, convergence. The method of successive approximations (Picard), Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

## References


[1] Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

[2] M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering

[3] Computation, 6th Ed., New age International Publisher, India, 2007.

[4] C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.

[5] Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.

[6] John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.

[7] Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.

[8] Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.

[9] Yashavant Kanetkar, Let Us C, BPB Publications.



Course Structure | DSE | SEC | Credit Distribution

# Numerical Methods Lab

| | |
|---|---|
| Semester : VI<br>Core Course-XIV Practical<br>Paper Code: MH(CC14 Pr)602 | Credits : 2<br>Full Marks : 30 |
| *Number of classes required* : 50 | |

Course Structure | DSE | SEC | Credit Distribution

## 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.**

Course Structure | DSE | SEC | Credit Distribution

# Rigid Dynamics

| | |
|---|---|
| Semester : V<br>Discipline Specific Elective-1<br>Paper Code: MH(DSE1 RD)503 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[40 classes]

- Degrees of freedom, Vector angular velocity and its existence, particle velocities in a rigid body,
- Rotating reference frames : velocity and acceleration transformation formulas.
- Moments and Products of Inertia, Moment of inertia of a body about any line through the origin of a coordinate frame, The theorems of parallel and perpendicular axes. The inertia tensor I,
- Angular momentum of a rigid body in terms of I and the kinetic energy of a rigid body rotating about a fixed point in terms of I. Principal axes and Principal moments of inertia. The momental ellipsoid - equimomental systems.

## Unit-2

[35 classes]

- **Problems in rigid body dynamics:**
  Equations of rigid body dynamics:
  (i) $M\frac{d\vec{v}}{dt} = \vec{F}$, $\frac{d\vec{L_G}}{dt} = \vec{K_G}$
  $M\frac{dV_x}{dt} = F_x$, $M\frac{dV_y}{dt} = F_y$, $I\frac{dw}{dt} = K_G$

  Motion of a rigid body about a fixed axis, Physical (compound) pendulum. Cases of rolling, sliding etc.

  (ii) Motion of a rigid body under an impulsive forces.

  (iii) Problems illustrating the law of conservation of angular motion.

  (iv) Problems illustrating law of conservation of energy.

## References

[1] Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press

Course Structure | DSE | SEC | Credit Distribution

# Advanced Algebra

| | |
|---|---|
| Semester : V<br>Discipline Specific Elective-1<br>Paper Code: MH(DSE1 RT)503 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1: Group Theory [25 classes]

- 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 [50 classes]

- 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

[1] John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

[2] M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

[3] Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.

[4] Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.

[5] D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.

[6] D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

Course Structure | DSE | SEC | Credit Distribution

# Bio Mathematics

| | |
|---|---|
| Semester : V<br>Discipline Specific Elective-1<br>Paper Code: MH(DSE1 BM)503 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[25 classes]

- Mathematical biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, bacterial growth in a chemostat, harvesting a single natural population, Prey predator systems and Lotka-Volterra equations, populations in competitions, epidemic models (SI, SIR, SIRS, SIC)

## Unit-2

[30 classes]

- Activator-inhibitor system, insect outbreak model: Spruce Budworm. Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria. Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario. Spatial models: One species model with diffusion. Two species model with diffusion, conditions for diffusive instability, spreading colonies of microorganisms, Blood flow in circulatory system, travelling wave solutions, spread of genes in a population.

## Unit-3

[15 classes]

- Discrete models : Overview of difference equations, steady state solution and linear stability analysis. Introduction to discrete models, linear models, growth models, decay models, drug delivery problem, discrete prey-predator models, density dependent growth models with harvesting, host-parasitoid systems (Nicholson- Bailey model), numerical solution of the models and its graphical representation. case studies. Optimal exploitation models, models in genetics, stage structure models, age structure models.

## Graphical Demonstration (Teaching Aid)[using any software]

[5 classes]

- 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


[1] L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.

[2] J. D. Murray, Mathematical Biology, Springer, 1993.

[3] Y.C. Fung, Biomechanics, Springer-Verlag, 1990.

[4] F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.

[5] M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.



Course Structure | DSE | SEC | Credit Distribution

# Discrete Mathematics

| | |
|---|---|
| Semester : V<br>Discipline Specific Elective-2<br>Paper Code: MH(DSE2 DM)504 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1 : Graph Theory [40 classes]

- Definition of undirected graphs, Using of graphs to solve different puzzles and problems. Multigraphs. Walks, Trails, Paths, Circuits and cycles, Eulerian circuits and paths. Eulerian graphs, example of Eulerian graphs. Hamiltonian cycles and Hamiltonian graphs.
- 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 $\mathcal{Z}_n^*$, the existence of primitive roots, applications of primitive roots, the algebraic structure of $\mathcal{Z}_n^*$.
- 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.

[2] John Clark and Derek Allan Holton; A First Look at Graph Theory; World Scientific, New Jersey, 1991.

[3] F. Harary; Graph Theory; Narosa Publishing House, New Delhi, 2001.

[4] J. A. Bondy and U. S. R. Murty; Graph theory and related topics; Academic Press, New York, 1979.

[5] Adhikari M R and Adhikari A: Basic Modern Algebra with Applications, Springer, 2014.

[6] Gareth A Jones and J Mary Jones : Elementary Number Theory, Springer International Edition.

[7] Neal Koblitz : A course in number theory and cryptography, Springer-Verlag, 2nd edition.

[8] D. M. Burton : Elementary Number Theory, Wm. C. Brown Publishers, Dulreque, Lowa, 1989.

[9] Kenneth. H. Rosen : Elementary Number Theory & Its Applications, AT&T Bell Laboratories, Addition-Wesley Publishing Company, 3rd Edition.

[10] Kenneth Ireland & Michael Rosen : A Classical Introduction to Modern Number Theory, 2nd edition, Springer-verlag.

[11] Richard A Mollin : Advanced Number Theory with Applications, CRC Press, A Chapman & Hall Book.

Course Structure | DSE | SEC | Credit Distribution

# Financial Mathematics

| | |
|---|---|
| Semester : V<br>Discipline Specific Elective-2<br>Paper Code: MH(DSE2 DE)504 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[35 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, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, putable and callable bonds.

## Unit-2

[40 classes]

- 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), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index.

## References

[1] David G. Luenberger, Investment Science, Oxford University Press, Delhi, 1998.

[2] John C. Hull, Options, Futures and Other Derivatives, 6th Ed., Prentice-Hall India, Indian reprint, 2006.

[3] J Robert Buchanan , An Undergraduate introduction to Financial Mathematics, World Scientific Publishing Co. Pte. Ltd, 2006.

[4] Sheldon Ross, An Elementary Introduction to Mathematical Finance, 2nd Ed., Cambridge University Press, USA, 2003.

Course Structure | DSE | SEC | Credit Distribution

# Fluid Statics & Elementary Fluid Dynamics

| | |
|---|---|
| Semester : V<br>Discipline Specific Elective-2<br>Paper Code: MH(DSE2 Hs)504 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[20 classes]

- **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: $\vec{\nabla} p = \rho \vec{F}$, Fundamental Fluid Static Equations in Scalar Form: $\frac{\partial p}{\partial z} = \rho g$, Constant Density Solution.

## Unit-2

[25 classes]

- **Hydrostatics**
  Hydrostatic Thrusts on Submerged Plane Surface: Centre of pressure, determination of coordinates of centre of pressure. Hydrostatic Thrusts on Submerged Curved Surfaces. Buoyancy: Center of the buoyancy. Archimedes principle. Stability of Unconstrained Submerged Bodies in Fluid: Stable Equilibrium, Unstable Equilibrium, Neutral Equilibrium. Stability of Floating Bodies in Fluid: Metacentre, Metacentric height.
- **Gas**
  Pressure of gases, The Atmosphere, Relation between pressure, density and temperature, Pressure in an isothermal atmosphere, Atmosphere in convective equilibrium.

## Unit-3

[15 classes]

- **Kinematics of Fluid:**
  Scalar and Vector Fields, flow field, Description of Fluid Motion: Lagrangian Method, Eulerian Method, Relation between Eulerian and Lagrangian Method, Variation of Flow Parameters in Time and Space: Steady and Unsteady Flow, Uniform and Non-uniform Flows. Material Derivative and Acceleration: temporal derivative, convective derivative

## Unit-4

[15 classes]

- **Conservation Equations:**
  Control Mass System, Control Volume System, Isolated System. Conservation of Mass - The Continuity Equation: Differential Form and Vector Form, Integral form. Conservation of Momentum: Momentum Theorem, Reynolds Transport Theorem. Conservation of energy.

## References

[1] Fox and McDonald's INTRODUCTION TO FLUID MECHANICS (8th edition) – Philips J. Pritchard, JOHN WILEY AND SONS INC .

[2] Fluid Mechanics (7th edition) – Frank M. White, McGraw Hill.

Course Structure | DSE | SEC | Credit Distribution

# Linear Programming

| | |
|---|---|
| Semester : VI<br>Discipline Specific Elective-3<br>Paper Code: MH(DSE3 LP)603 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment & Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[15 classes]

- Definition of Linear Programming Problem (L.P.P.). Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and Basic Feasible Solution (B.F.S) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.
- 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]

- Slack and surplus variables. Standard form of L.P.P. theory of simplex method. Feasibility and optimality conditions.
- The algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

## 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]

- Transportation and Assignment problems. Mathematical justification for optimality criterion. Hungarian method. Traveling Salesman problem.
- Concept of game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of rectangular games. Algebraic method. Graphical method and Dominance method of solving Rectangular games. Inter-relation between theory of games and L.P.P.

## References

[1] Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.

[2] F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.

[3] Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.

[4] G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Course Structure | DSE | SEC | Credit Distribution

# Boolean Algebra & Automata Theory

| | |
|---|---|
| Semester : VI<br>Discipline Specific Elective-3<br>Paper Code: MH(DSE3 BA)603 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[10 classes]

- 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

[15 classes]

- 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

[15 classes]

- 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

[15 classes]

- 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

[10 classes]

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

## Unit-6

[10 classes]

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

## References

[1] B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.

[2] Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.

[3] Rudolf Lidl and G$\ddot{u}$nter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

[4] J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages, and Computation, 2nd Ed., Addison-Wesley, 2001.

[5] H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997.

[6] J.A. Anderson, Automata Theory with Modern Applications, Cambridge University Press, 2006

Course Structure | DSE | SEC | Credit Distribution

# Differential Geometry

| | |
|---|---|
| Semester : VI<br>Discipline Specific Elective-3<br>Paper Code: MH(DSE3 DG)603 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[15 classes]

- Tensor : Different transformation laws, Properties of tensors, Metric tensor, Riemannian space, Covariant Differentiation, Einstein space.
- Theory of space curves : Space curves. Planer curves, curvature, torsion and Serret-Frenet formula. Osculating circles, osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

## Unit-2

[30 classes]

- Theory of surfaces : Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula. Conjugate and asymptotic lines.

## Unit-3

[30 classes]

- Developables : Developable associated with space curves and curves on surfaces. Minimal surfaces. Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem.

## References

[1] T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.

[2] B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.

[3] C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.

[4] D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.

[5] S. Lang, Fundamentals of Differential Geometry, Springer, 1999.

[6] B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003.

[7] An Introduction to Differential Geometry (with the use of tensor Calculus), L. P. Eisenhart, Princeton University Press, 1940.

[8] Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continua, 2nd Edition, I. S. Sokolnikoff, John Wiley and Sons., 1964.

Course Structure | DSE | SEC | Credit Distribution

# Point Set Topology

| | |
|---|---|
| Semester : VI<br>Discipline Specific Elective-4<br>Paper Code: MH(DSE4 ST)604 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[35 classes]

- 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

[15 classes]

- 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

[25 classes]

- 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-Weiertrass property of $X$ are equivalent.

## References

[1] Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt.Ltd.,New Delhi, 2000.

[2] Dugundji, J., Topology, Allyn and Bacon, 1966.

[3] Simmons, G.F., Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

[4] Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York,1995.

[5] Hocking, J., Young, G., Topology, Addison-Wesley Reading, 1961.

[6] Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart andWinston, New York, 1970.

Course Structure | DSE | SEC | Credit Distribution

# Astronomy

| | |
|---|---|
| Semester : VI<br>Discipline Specific Elective-4<br>Paper Code: MH(DSE4 As)604 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[25 classes]

- 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

[15 classes]

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

## Unit-3

[10 classes]

- Various magnitudes of stars: apparent, absolute, photovisual, photographic, bolometric etc. Distance measurements of stars: Parallax method, Statistical Palallax Method, Moving Cluster Method. Radial and proper motion. Exercises.

## Unit-4

[10 classes]

- Morphological structure of Sun, solar cycles, sunspots, solar corona, solar wind, solar neutrino puzzle (Merely descriptive models). Solar system.

## Unit-5

[10 classes]

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

## Unit-6

[5 classes]

- Morphological classification of galaxies, rotation curves and mass modelling, missing mass and dark matter, distance determination by various methods. Our Galaxy. Exercises.

## References

[1] T. Padmanabhan, Theoretical Astrophysics, vols. 1-3, Cambridge University Press, 2002.

[2] S. Weinberg, Gravitation and Cosmology, Wiley, 2001.

[3] J.V. Narlikar, Introduction to Cosmology, Cambridge University Press, 2002.

[4] J.V. Narlikar, An Introduction to Relativity, Cambridge University Press, 2010.

[5] B.Basu, T.Chattopadhyay and S.N.Biswas, An Introduction to Astrophysics, Prentice Hall of India, 2010.

[6] Physical Processes in the Interstellar Medium, Lyman Spitzer, Jr. Wiley, 1998.

[7] Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press, 2010.

[8] Extragalactic Astronomy and Cosmology: An Introduction, Peter Scineider, Springer, 2006.

[9] Textbook on Spherical Astronomy, W.M. Smart , Cambridge University Press.

[10] A Text Book on Astronomy, K.K. De, Books Syndicate (P) Ltd. 2013.

Course Structure | DSE | SEC | Credit Distribution

# Advanced Mechanics

| | |
|---|---|
| Semester : VI<br>Discipline Specific Elective-4<br>Paper Code: MH(DSE4 AM)604 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 75 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | DSE | SEC | Credit Distribution

## Unit-1

[20 classes]

- Centre of Gravity: General formula for the determination of Centre of Gravity. Determination of position of Centre of Gravity of any arc, area of solid of known shape by method of integration.
- Astatic Equilibrium, Astatic centre, Positions of equilibrium of a particle lying on a smooth plane curve under the action of given force. Action at a joint in a frame work.

## Unit-2

[15 classes]

- Mechanics of a system of particles : Constraints :- unilateral, bilateral; Virtual displacement and principle of virtual work.

## Unit-3

[20 classes]

- Degrees of freedom, reactions due to constraints. D' Alembert's principle; Lagranges 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-4

[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.

## References

[1] H. Goldstein, Classical Mechanics, Narosa Publ., New Delhi, 1998.

[2] N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 2002.

[3] E.T. Whittaker, A Treatise of Analytical Dynamics of Particles and Rigid Bodies, Cambridge Univ. Press, Cambridge, 1977.

[4] F. Gantmacher, Lectures in Analytical Mechanics, Mir Publ., 1975.

[5] T.W.B. Kibble and F.H. Berkshire, Classical Mechanics, 4th ed., Addison-Wesley Longman, 1996.

[6] V.I. Arnold, Mathematical Methods of Classical Mechanics, 2nd ed., Springer-Verlag, 1997.

[7] N.G. Chetaev, Theoretical Mechanics, Springer-Verlag, 1990.

[8] M. Calkin, Lagrangian and Hamiltonian Mechanics, World Sci. Publ., Singapore, 1996.

[9] J.L. Synge and B.A. Griffith, Principles of Mechanics, McGraw Hill, Singapore, 1970.

[10] E.C.G. Sudarshan and N. Mukunda, Classical Dynamics: A Modern Perspectives, John Wiley & Sons, 1974.

[11] J.R. Taylor, Classical Mechanics, University Science Books, California, 2005.

[12] L.D. Landau and E.M. Lifshitz, Mechanics, 3rd ed., Pergamon Press, 1982.

Course Structure | DSE | SEC | Credit Distribution

# C Programming Language

| | |
|---|---|
| Semester : III<br>Skill Enhancement Course-1 (Practical)<br>Paper Code: MH(SEC1 CPL)304 | Credits : 2<br>Full Marks : 30 |
| *Number of classes required* : 50 | |

Course Structure | DSE | SEC | Credit Distribution

**Two problems are to be solved during the Practical Examination using the following concepts of C Programming language.**

[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

[1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.

[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004.

[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.

[4] C. Xavier : C-Language and Numerical Methods, New Age International.

[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980.

Course Structure | DSE | SEC | Credit Distribution

# Object Oriented Programming in C++

| | |
|---|---|
| Semester : III<br>Skill Enhancement Course-1 (Practical)<br>Paper Code: MH(SEC1 OOP)304 | Credits : 2<br>Full Marks : 30 |
| *Number of classes required* : 50 | |

Course Structure | DSE | SEC | Credit Distribution

**Two problems are to be solved during the Practical Examination using the following concepts of C++ Programming language.**

## 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.

- **List of practicals (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. 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.

## References

[1] Arnold Robbins, Linux Programming by Examples The Fundamentals, 2nd Ed., Pearson Education, 2008.

[2] Cox K, Red Hat Linux Administrator's Guide, PHI, 2009.

[3] R. Stevens, UNIX Network Programming, 3rd Ed., PHI, 2008.

[4] Sumitabha Das, UNIX Concepts and Applications, 4th Ed., TMH, 2009.

[5] Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, Linux in a Nutshell, 6th Ed.,O'Reilly Media, 2009.

[6] Neil Matthew, Richard Stones, Alan Cox, Beginning Linux Programming, 3rd Ed., 2004.

Course Structure | DSE | SEC | Credit Distribution

# Mathematical Logic

| | |
|---|---|
| Semester : IV<br>Skill Enhancement Course-2<br>Paper Code: MH(SEC2 ML)404 | Credits : 2<br>Full Marks : 30 |
| *Number of classes required* : 30 | |

Course Structure | DSE | SEC | Credit Distribution

## 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, Leindenbaum 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

[1] Elliott Mendelson; Introduction to mathematical logic; Chapman & Hall; London(1997)

[2] Angelo Margaris; First order mathematical logic; Dover publications, Inc, New York (1990).

[3] S.C.Kleene; Introduction to Metamathematics; Amsterdam; Elsevier (1952).

[4] J.H.Gallier; Logic for Computer Science; John.Wiley & Sons (1987).

[5] H.B.Enderton; A mathematical introduction to logic; Academic Press; New York (1972).

Course Structure | DSE | SEC | Credit Distribution

## Scientific computing with SageMath/Mathematica

| | |
|---|---|
| Semester : IV<br>Skill Enhancement Course-2 (Practical)<br>Paper Code: MH(SEC2 SC)404 | Credits : 2<br>Full Marks : 30 |
| *Number of classes required* : 50 | |

Course Structure | DSE | SEC | Credit Distribution

**Two problems are to be solved during the Practical Examination using the following concepts of SageMath/Mathematica.**

[30 classes]

- Introduction to SageMath/Mathematica/Matlab, Installation Procedure, Use of SageMath/Mathematica/Matlal 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/Mathematica/Matlab commands for differentiation, higher order derivatives, plotting $f(x)$ and $f'(x)$ together, integrals, definite integrals etc.
- Introduction to Programming in SageMath/Mathematica/Matlab, 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.

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

## References

[1] The Student's Introduction to MATHEMATICA: A Handbook for Precalculus, Calculus, and Linear Algebra 2nd Edition by Bruce F. Torrence, Eve A. Torrence, Cambridge University Press, 2009.

[2] An Introduction to SAGE Programming : With Applications to SAGE, Razvan A. Mezei, Wiley,

[3] http://doc.sagemath.org/pdf/en/tutorial/SageTutorial.pdf

[4] Stormy Attaway, MATLAB: A Practical Introduction to Programmming and Problem Solving, College of Engineering, Boston University, Boston, Ma, Matlab:

Course Structure | DSE | SEC | Credit Distribution

# Introduction to MATLAB

| | |
|---|---|
| Semester : IV<br>Skill Enhancement Course-2 (Practical)<br>Paper Code: MH(SEC2 MLAB)404 | Credits : 2<br>Full Marks : 30 |
| *Number of classes required* : 50 | |

Course Structure | DSE | SEC | Credit Distribution

**Two problems are to be solved during the Practical Examination using the following concepts of MATLAB.**

[30 classes]

- Starting Up: Matlab windows, working in the command window, arithmetic operations with scalars, Matlab as a calculator , display formats, elementary math built-in functions. Assignment operator , variable names, predefined variables and keywords, commands for managing variables , creating and saving and running a script file.
- Arrays: One-dimensional array (vector), two-dimensional array (matrix), the zeros, ones and eye commands , transpose operator. Array addressing, using a colon, adding elements to existing variables, deleting elements, built-in functions for handling arrays, strings and strings as variables.
- Mathematical Operations with Arrays: addition and subtraction, multiplication, division, element-by-element operations.
- Two-Dimensional Plots: plot of given data, plot of a function. The fplot command, formatting a plot using commands, plotting multiple plots on the same page.
- Programming in MATLAB: relational and logical operators, conditional statements, the if-end structure, the if-else-end structure , the if-elseif-else-end structure, the switch-case statement, loops, for-end loops, while-end loops, nested loops and nested conditional statements, the break and continue commands.
- User-Defined Functions and Function Files: creating a function file, structure of a function file, examples of simple user-defined functions. Subfunctions, nested functions
- Applications: value of a polynomial, roots of a polynomial, addition, multiplication, and division of polynomials, solving an equation with one variable, finding a minimum or a maximum of a function, system of linear equations.

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

## References

[1] MATLAB an Introduction with Applications (4th edition), Amos Gilat, John Wiley sons, inc.

[2] An Introduction to Programming and Numerical Methods in MATLAB, S.R. Otto and J.P. Denier, Springer-Verlag.

[3] A Guide to MATLAB for Beginners and Experienced Users, Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, Cambridge university press.

[4] Stormy Attaway, MATLAB: A Practical Introduction to Programmming and Problem Solving, College of Engineering, Boston University, Boston, Ma, Matlab:

[5] Matlab Primer, Timothy A. Davis, CRC Press.

Course Structure | DSE | SEC | Credit Distribution

# Choices for Generic Electives (GE)

[To be taken by the students of other discipline]

| Semester | Course Name | Course Detail | Full Marks | Page No. | Credit |
|---|---|---|---|---|---|
| I | Generic Elective-1 | Algebra-I | 15 | 55 | 6 |
| | | Differential Calculus-I | 25 | | |
| | | Differential Equation-I | 15 | | |
| | | Coordinate Geometry | 25 | | |
| II | Generic Elective-2 | Differential Calculus-II | 20 | 57 | 6 |
| | | Differential Equation-II | 15 | | |
| | | Vector Algebra | 15 | | |
| | | Discrete Mathematics | 30 | | |
| III | Generic Elective-3 | Integral Calculus | 20 | 59 | 6 |
| | | Numerical Methods | 30 | | |
| | | Linear Programming | 30 | | |
| IV | Generic Elective-4 | Algebra-II | 20 | 61 | 6 |
| | | Computer Science & Programming | 30 | | |
| | | Probability & Statistics | 30 | | |
| | | **Total** | **320** | | **24** |
| | | **Internal Assessment** | $20 \times 4 = 80$ | | |
| | | **Grand Total** | **400** | | |

Course Structure | DSE | SEC | Credit Distribution

# Generic Elective-1

| | |
|---|---|
| Semester : I<br>Generic Elective-1<br>Paper Code: MG(GE1)101 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 60 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | GE | Credit Distribution

## Unit-1 : Algebra-I

- 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

- 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. Acqutance (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.
- Derivative - its geometrical and physical interpretation. Sign of derivative-Monotonic increasing and decreasing functions. Relation between continuity and derivability. Differential - application in finding approximation.
- 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.
- Applications of Differential Calculus : Curvature of plane curves. Rectilinear Asymptotes (Cartesian only). Envelope of family of straight lines and of curves (problems only). Definitions and examples of singular points (Viz. Node. Cusp, Isolated point).

## Unit-3 : Differential Equation-I

- 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 BernoulliÃâ̂s equations (Linear). (iii) Clairaut's Equations : General and Singular solutions.
- Second order linear equations : Second order linear differential equation with constant co-efficients. Euler's Homogeneous equations.
- Second order differential equation : (i) Method of variation of parameters, (ii) Method of undetermined coefficients.

## Unit-4 : Coordinate Geometry

- 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.

Course Structure | GE | Credit Distribution

# Generic Elective-2

| | |
|---|---|
| Semester : II<br>Generic Elective-2<br>Paper Code: MG(GE2)201 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 60 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | GE | Credit Distribution

## Unit-1 : Differential Calculus-II

- 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.
- Infinite series of constant terms; Convergence and Divergence (definitions). Cauchy's principle as applied to infinite series (application only). Series of positive terms : Statements of comparision test. D.AIembert's Ratio test. Cauchy's nth root test and Raabe's test Applications. Alternating series. Statement of Leibnitz test and its applications.
- 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

- Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Simple eigenvalue problem.
- Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.

## Unit-3 : Vector Algebra

- Addition of Vectors, Multiplication of a Vector by a Scalar. Collinear and Coplanar Vectors. Scalar and Vector products of two and three vectors. Simple applications to problems of Geometry. Vector equation of plane and straight line. Volume of Tetrahedron. Applications to problems of Mechanics (Work done and Moment).

## Unit-4 : Discrete Mathematics

- Integers : Principle of Mathematical Induction. Division algorithm. Representation of integer in an arbitrary base. Prime Integers. Some properties of prime integers. Fundamental theorem of Arithmetic. Euclid's Theorem. Linear Diophantine equations. [Statement of Principle of Mathematical Induction, Strong form of Mathematical induction. Applications in different problems. Proofs of division algorithm. Representation of an integer uniquely in an arbitrary base, change of an integer from one base to another base. Computer operations with integers, Divisor of an integer, g.c.d. of two positive integers, prime integer, Proof of Fundamental theorem, Proof of Euclid's Theorem. To show how to find all prime numbers less than or equal to a given positive integer. Problems related to prime number. Linear Diophantine equation , when such an equation has solution, some applications.]
- Congruences : Congruence relation on integers, Basic properties of this relation. Linear congruences, Chinese Remainder Theorem. System of Linear congruences. [Definition of Congruence, show it is an equivalence relation, to prove the following : $a \equiv b \pmod{m}$ implies
(i) $(a+c) \equiv (b+c) \pmod{m}$
(ii) $ac \equiv bc \pmod{m}$
(iii) $a^n \equiv b^n \pmod{m}$, 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 , Statement and proof and some applications. System of linear congruences, when solution exists, 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, 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. [Definition of Congruence Classes, properties of Congruence classes, addition and multiplication, existence of inverse. Fermat's little theorem. Euler's theorem. Wilson's theorem, Statement, proof and some applications.]
- Boolean algebra : Boolean Algebra, Boolean functions, Logic gates, Minimization of circuits.

Course Structure | GE | Credit Distribution

# Generic Elective-3

| | |
|---|---|
| Semester : III<br>Generic Elective-3<br>Paper Code(GE3)301 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 60 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment & Attendance (10 marks for each) | |

Course Structure | GE | Credit Distribution

## Unit-1 : Integral Calculus

- Evaluation of definite integrals.
- Integration as the limit of a sum (with equally spaced as well as unequal intervals).
- Reduction formulae of $\int \sin^n x \cos^m x dx$, $\int \frac{\sin^m x}{\cos^n x} dx$, $\int \tan^n x dx$ 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, Quardrature, volume and surface areas of solids formed by revolution of plane curve and areas problems only.

## Unit-2 : Numerical Methods

- 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). NewtonÃâs 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 $\frac{1}{3}$-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

- Motivation of Linear Programming problem. Statement of L.P.P. Formulation of L.P.P. Slack and Surplus variables. L.P.P. is matrix form. Convex set, Hyperplane, Extreme points, convex Polyhedron, Basic solutions and Basic Feasible Solutions (B.F.S.). Degenerate and Non-degenerate B.F.S.
- 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.

Course Structure | GE | Credit Distribution

# Generic Elective-4

| | |
|---|---|
| Semester : IV<br>Generic Elective-4<br>Paper Code: MG(GE4)401 | Credits : 5+1*=6<br>Full Marks : 80+20**=100 |
| *Number of classes required* : 60 | |
| *1 Credit for Tutorial | |
| **20 Marks are reserved for Internal Assessment<br>& Attendance (10 marks for each) | |

Course Structure | GE | Credit Distribution

## Unit-1 : Algebra-II

- 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

- Computer Science and Programming : Historical Development, Computer Generation, Computer Anatomy Different Components of a computer system. Operating System, hardware and Software.
- 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

- Elements of probability Theory : Random experiment, Outcome, Event, Mutually Exclusive Events, Equally likely and Exhaustive. Classical definition of probability, Theorems of Total Probability, Conditional probability and Statistical Independence. Baye's Theorem. Problems, Shortcoming of the classical definition. Axiomatic approach problems, Random Variable and its Expectation, Theorems on mathematical expectation. Joint distribution of two random variables.
- Theoretical Probability Distribution Discrete and Continuous (p.m.f., p.d.f.) Binomial, Poisson and Normal distributions and their properties.

- Elements of Statistical Methods. Variables, Attributes. Primary data and secondary data, Population and sample. Census and Sample Survey. Tabulation Chart and Diagram, Graph, Bar diagram, Pie diagram etc. Frequency Distribution Un-grouped and grouped cumulative frequency distribution. Histogram, Frequency curve, Measures of Central tendencies. Averages : AM,; GM, HM, Mean, Median and Mode (their advantages and disadvantages). Measures of Dispersions - Range, Quartile Deviation, Mean Deviation, Variance / S.D., Moments, Skewness and Kurtosis.
- Sampling Theory : Meaning and objects of sampling. Some ideas about the methods of selecting samples, Statistic and parameter, Sampling Proportion. Four fundamental distributions, derived from the normal: (i) standard Normal Distribution, (ii) Chi-square distribution (iii) Student's distribution (iv) Snedecor's F-distribution. Estimation and Test of Significance. Statistical Inference. Theory of estimation Point estimation and Interval estimation. Confidence Interval / Confidence Limit. Statistical Hypothesis - Null Hypothesis and Alternative Hypothesis. Level of significance. Critical Region. Type I and II error. Problems.
- Bivariate Frequency Distribution. Scatter Diagram, Co-relation co-efficient Definition and properties. Regression lines.

Course Structure | GE | Credit Distribution