Choice Based Credit System (CBCS)

NOWGONG COLLEGE
(AUTONOMOUS)

SYLLABUS

DEPARTMENT OF MATHEMATICS

Learning Outcomes-based Curriculum Framework (LOCF) of
Undergraduate Programme

BACHELOR OF ARTS/SCIENCE IN MATHEMATICS

(Effective from Academic Year 2020-21)

Syllabus as approved by Academic Council, Nowgong College (Autonomous)

Details Syllabus

Department of Mathematics

Nowgong College (Autonomous)

1. Introduction to the Program

B.Sc. (Honours) Mathematics is a three-year undergraduate program with specialization in Mathematics. The program fosters interdisciplinary approach to the study of Mathematics, Computers and Statistics, aiming to promote holistic education useful in handling social, economics, engineering, physical and computer -sciences problems. The curriculum is dispensed using a combination of classroom teaching, project-based learning, practical using different types of software, group discussions, presentations, home assignments.

B.Sc. (Honours) Mathematics program is designed in such a way that students will be exposed to the real-world data related to industries and society, identifying the problems and working towards their solutions through various analytical and Mathematics techniques. The course is designed in such a way that students can absorb strong foundation of Mathematics .

2.Program Structure

The B.Sc. Mathematics is a three-year program divided into six semesters. A student is required to complete 148 credits for the completion of program as Honours student and 132 credits for the completion of program as Regular student.

The B.Sc. (Honours Course) in Mathematics program is aligned with CBCS structure as –

Honours Course		**Theory with Practical**		
		Theory	**Practical**	**Total**
Honours Core Course HCC (14 Papers)		5x4=20 9x6=54	5x2=10	84
Discipline Specific Elective Course HDS (4 Papers)		4x6=24		24
Honours Generic Elective Course HGE (4 Papers)		4x6=24		24
Ability Enhancement Course AEC	Communication Language (1 Paper)	1x4=4	0	4
	Environmental Studies (1 Paper)	1x4=4	0	4
Skill Enhancement Course SEC (2 Papers)		2x2=4	2x2=4	8
Total		134	14	148

3. Program Objectives:

Students who choose B.Sc. (Honours) Mathematics Program, develop the ability to think critically, logically and analytically and hence use mathematical reasoning in everyday life.

The students will be introduced a number of interesting and useful ideas in preparations for a number of mathematics careers in education, research, government sector and industry.

The program almost covers the basic ideas in pure and applied mathematics. The course structure of the program consists of the foundation of Calculus, Real and Complex analysis, Algebra (Modern ,Higher, Boolean and Linear) Differential equations (Ordinary and Partial) , Hydromechanics,

Mechanics, Geometry and Metric Spaces. The practical part of the program are done by using different types of software like MATLAB/ MATHEMATICA/ MAPLE etc in Computer Lab.
Numerical Analysis, Linear Programming and Applications are also introduced to create the interests and ambitions.

4. Program Learning Outcomes : The completion of the B.Sc. (Honours) Mathematics Program shall enable a student:
i) A holistic knowledge and understanding of basic concepts in computational and graphic means.
ii)The capacity to identify, understand and solve the problems of society.
iii) Create mathematical ideas from basic axioms.
iv) To enable the students to understand basic concepts and aspects related to research, various techniques to collect the data to analyze the data and interpret the results there after.
v) Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.
vi) Identify applications of mathematics in other disciplines and in the real world, leading to enhancement
of career different fields.

5. Teaching Learning Process

The Department of Mathematics at Nowgong College (Autonomous) is primarily responsible for organizing the Bachelor of Science course (Honours) in Mathematics. Tutorial and practice related instructions are provided by the respective registering units under the general guidance of Department of Mathematics of Nowgong College (Autonomous)
There shall be 90 instructional days excluding examination in a semester.

6. Teaching Pedagogy

Teaching Pedagogy involves classroom interaction, discussion, lectures, course-based practical work, viva-voce, mock test, demonstration, presentation, classroom tests, and assignments. The achievement of course is described in each course papers as learning outcomes in detail.

7. Assessment Methods/Evaluation System

The students registered for academic program will study semester I to VI at the Nowgong College (Autonomous) and during these semesters Core, AECC, HDS, RDS and SEC courses are offered.

(i) English shall be the medium of instruction and examination for Honours course and English/Assamese for Generic Elective course and Regular course.
(ii)Examinations shall be conducted at the end of each Semester as per the Academic calendar notified by the Nowgong College (Autonomous).
(iii)The assessment broadly comprises of Internal Assessment (Sessional Examination, Attendance, Assignments) and End Semester Examination.
(iv)Theory papers without practical/presentation i.e only Ability Enhancement Compulsory Course (AEC) Papers consist of total 100 marks divided into 80 marks for theory, 20 marks for internal assessment.
(v)Theory papers with practical/presentation i.e Core Courses (CCC- ENGL; CCC-ASSA, HIND, BENG and ALEN; HCC; RCC). Discipline Specific Electives (HDS & RDS), Generic Electives (HGE & RGE), Skill Enhancement Courses (SEC) consist of total 100 marks divided into 60 marks for theory, 20 marks for internal assessment and 20 marks for Practical/Presentation.

(vi)Internal assessment of 20 marks is comprises with 06 marks from assignment, 10 marks from sessional examination and 4 marks from attendance.
(vii)Each practical paper will carry 20 marks including 15 marks for continuous evaluation and 2 marks for practical note book and 3 marks for the oral test or *viva voce*.
Hardcopy of practical file has to be maintained by the students for each practical paper and has to be submitted in the concerned department at the time of examination.
(viii)Each presentation will carry 20 marks including 15 marks for continuous evaluation and 2 marks for presented report and 3 marks for the oral test or *viva voce*. The departments will decide the process of continuous evaluation for the task carried-out against the presentation.
Hardcopy of the report has to be maintained by the students for each presented paper and has to be submitted in the concerned department at the time of examination.

8. SYLLABUS STRUCTURES

DEPARTMENT OF MATHEMATICS

NOWGONG COLLEGE(AUTONOMOUS)

NAGAON ASSAM (Undergraduate Science Honours Course)

Semester	Honours Core Course 14x6=84	Ability Enhancement Course 2x4=8	Skill Enhancement Course 2x4=8	DSE 4x6=26	Honours Generic Elective 4x6=24
SEM-I	Course-I Course-II From same Discipline MATH-HCC-1016 MATH-HCC-1026	Communicative English ENGL-AEC-1014			One course for any Discipline except Honours Discipline MATH-HGE-1016
SEM-II	Course-I Course-II From same Discipline MATH-HCC-2016 MATH-HCC-2026	Communicative English ENGL-AEC-2014			One course for any Discipline except Honours Discipline MATH-HGE-2016
SEM-III	Course-I Course-II From same Discipline MATH-HCC-3016 MATH-HCC-3026 MATH-HCC-3036		MATH-SEC-3014		MATH-HGE-3016
SEM-IV	Course-I Course-II From same Discipline MATH-HCC-4016 MATH-HCC-4026 MATH-HCC-4036		MATH-SEC-4014		MATH-HGE-4016
SEM-V	Course-I Course-II From same Discipline MATH-HCC-5016 MATH-HCC-5026			MATH-HDS-5016 MATH-HDS-5026	
SEM-VI	Course-I Course-II From same Discipline MATH-HCC-6016 MATH-HCC-6026			MATH-HDS-6016 MATH-HDS-6026 Dissertation/Project	

9. Undergraduate Honours-Arts: (Total credit = 148)

(For Mathematics Honours)

Semester	Honours Core Course 14x6=84	Ability Enhancement Course 2x4=8	Skill Enhancement Course 2x4=8	DSE 4x6=26	Honours Generic Elective 4x6=24
SEM-I	Course-I Course-II From same Discipline MATH-HCC-1016 MATH-HCC-1026	Communicative English/MIL(Any one) ENGL-AEC-1014 ASSA-AEC-1014 HIND-AEC-1014 BENG-AEC-1014			One course for any Discipline except Honours Discipline XXXX-HGE-1016
SEM-II	Course-I Course-II From same Discipline MATH-HCC-2016 MATH-HCC-2026	Environment Studies ENST-AEC-2014			One course for any Discipline except Honours Discipline XXXX-HGE-2016
SEM-III	Course-I Course-II From same Discipline MATH-HCC-3016 MATH-HCC-3026 MATH-HCC-3036		MATH-SEC-3014		XXXX-HGE-3016
SEM-IV	Course-I Course-II From same Discipline MATH-HCC-4016 MATH-HCC-4026 MATH-HCC-4036		MATH-SEC-4014		XXXX-HGE-4016
SEM-V	Course-I Course-II From same Discipline MATH-HCC-5016 MATH-HCC-5026			MATH-HDS-5016 MATH-HDS-5026	
SEM-VI	Course-I Course-II From same Discipline MATH-HCC-6016 MATH-HCC-6026			MATH-HDS-6016 MATH-HDS-6026 Dissertation/Project	

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10. Undergraduate Regular-Science

(Total credit = 132)

12 Core courses each of 6 credits;

6 Discipline Specific Elective courses each of 6 credits;

2 AE courses 4 credits each;

4 SE courses 4 credit each.

Undergraduate Science Regular

Semester	Regular Core Course 14x6=84	Ability Enhancement Course 2x4=8	Skill Enhancement Course 4x4=16	RDS 6x6=36
SEM-I	Course-I MATH-RCC-1016 Course-II XXXX-RCC-1016 Course-III XXXX-RCC-1016	Communicative English ENGL-AEC-1014		
SEM-II	Course-I MATH-RCC-2016 Course-II XXXX-RCC-2016 Course-III XXXX-RCC-2016	Environment Studies ENST-AEC-2014		
SEM-III	Course-I MATH-RCC-3016 Course-II XXXX-RCC-3016 Course-III XXXX-RCC-3016		MATH-SEC-3014	
SEM-IV	Course-I MATH-RCC-4016 Course-II XXXX-RCC-4016 Course-III XXXX-RCC-4016		MATH-SEC-4014	
SEM-V			XXXX-SEC-5014	Course-I MATH-RDS-5016 Course-II XXXX-RDS-5016 Course-III XXXX-RDS-5016
SEM-VI			XXXX-SEC-6014	Course-I MATH-RDS-6016 Course-II XXXX-RDS-6016 Course-III XXXX-RDS-6016

11. SYLLABUS FOR UNDER GRADUATE MATHEMATICS

1. MATH-HCC-1016: Calculus (including practical)
2. MATH-HCC -1026: Algebra
3. MATH-HCC -2016: Real Analysis
4. MATH-HCC -2026: Differential Equations (including practical)
5. MATH-HCC -3016: Theory of Real Functions
6. MATH-HCC -3026: Group Theory-I
7. MATH-HCC -3036: Analytical Geometry
8. MATH-HCC -4016: Multivariate Calculus
9. MATH-HCC -4026: Numerical Methods (including practical)
10. MATH-HCC -4036: Ring Theory
11. MATH-HCC -5016: Riemann Integration and Metric spaces
12. MATH-HCC -5026: Linear Algebra
13. MATH-HCC -6016: Complex Analysis (including practical)
14. MATH-HCC -6026: Partial Differential Equations (including practical)

Skill Enhancement Course (SEC) paper

SEC

MATH-SEC-3014: Computer Algebra Systems and Related Software

SEC 2

MATH-SEC-4014: R-Programming

Honours Discipline Specific (HDS) papers/Regular Discipline Specific(RDS) paper

HDS -1/RDS-1

MATH-HDS-5016/ MATH-RDS-5016: Linear Programming

HDS – 2

MATH-HDS-5026: Hydromechanics

HDS –3/

MATH-HDS-6016: Boolean Algebra

HDS –4

MATH-HDS-6026 (Dissertation/ Project/)

RDS-2

MATH-RDS-6016: Mechanics

Honours Generic Elective (HGE)/ Regular Core Course (RCC) papers

HGE -1 (choose one)

(i). MATH-HGE-1016A/MATH-RCC-1016: Calculus

(ii). MATH-HGE-1016B: Analytic Geometry

HGE- 2 (Choose one)

(i). MATH-HGE-2016A/MATH-RCC-2016: Algebra

(ii). MATH-HGE-2016B: Discrete Mathematics

HGE -3 (choose one)

(i). MATH-HGE-3016A/MATH-RCC-3016: Differential Equations

(ii). MATH-HGE-3016B: Linear Programming

HGE- 4

(i). MATH-HGE-4016/MATH-RCC-4016: Real Analysis

NOWGONG COLLEGE (AUTONOMOUS)

B.Sc./B.A Syllabus in Mathematics

Honours Core Course (HCC), Honours Generic Elective (HGE) and Regular Core Course (RCC)

Detailed Syllabus

SEMESTER-I

12. MATH-HCC-1016: Calculus (including practical)

Total marks: 100 (Theory: 60, Practical 20, Internal Assessment: 20)

Lectures 2 Practical, Credits 6 (4+2)

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful in understanding their applications in planetary motion, design of telescope and to the realworld problems. Also, computer lab will help to have a deep conceptual understanding of the above tools in true sense.

Course Learning Outcomes: This course will enable the students to:

i) Learn first and second derivative tests for relative extremum and apply the knowledge in problems in business, economics and life sciences.

ii) Sketch curves in a plane using its mathematical properties in different coordinate systems.

iii) Compute area of surfaces of revolution and the volume of solids by integrating over cross sectional areas.

iv) Understand the calculus of vector functions and its use to develop the basic principles of planetary motion.

UNIT 1: Higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$,concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L' Hopital's rule, applications in business, economics and life sciences.

Marks 20

[1]: Chapter 4 (Sections 4.3-4.7).

[2]: Chapter 6 (Section 6.1-6.8), Chapter 10 (Section 10.1-10.6).

UNIT 2: Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^m x dx$, volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Marks 20

[1]: Chapter 9 (Sections 9.4).

[2]: Chapter 7 (Sections 7.1-7.5), Chapter 5 (Section 5.1-5.5 (excluding arc length by numerical methods))

UNIT 3: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modelling ballistics and planetary motion, Kepler's law.

Marks 20

[1] Chapter 9 (Section 9.3), Chapter 10

Practical / Lab work to be performed on a computer: **Marks 20**

List of the practical to be done using Matlab / Mathematica / Maple / Scilab / Maxima etc.

(i). Plotting the graphs of the following functions: ax, $[x]$ (greatestinteger function),

$$\sqrt{ax+b}, |ax+b|, c\pm|ax+b|, x^{\pm n}, x^{1/n}, n\in Z$$

$$|x|/x,\ \sin(1/x),\ x\sin(1/x),\ \text{and},\ e^{\pm 1/x} \text{ for } x\neq 0.$$

$$e^{ax+b},\ \log(ax+b),\ 1/(ax+b),\ \sin(ax+b),\ \cos(ax+b),\ |\sin(ax+b)|,\ |\cos(ax+b)|.$$

Observe and discuss the effect of changes in the real constants a, b and c on the graphs.

(ii). Plotting the graphs of polynomial of degree 4 and 5, the graphs of their first andsecond derivatives, and analysis of these graphs in context of the concepts covered in Unit 1.

(iii). Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid and Hypocycloid.

(iv). Tracing of conic in cartesian coordinates.

(v). Obtaining surface of revolution of curves.

(vi). Graph of hyperbolic functions.

(vii). Computation of limit, Differentiation, Integration and sketching of vector-valued functions.

(viii). Complex numbers and their representations, Operations like addition, Multiplication, Division, Modulus. Graphical representation of polar form.

(ix). Find numbers between two real numbers and plotting of finite and infinite subset of R

Text Books:

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

2. H. Anton, I. Bivens and S. Davis, Calculus (10th Edition), John Wiley and sons (Asia), Pt Ltd., Singapore, 2011.

13. MATH-HCC-1026:Algebra

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week:5 Lectures 1 Tutorial, Credits 6,

Course Objectives: The primary objective of this course is to introduce the basic tools of set theory, functions, induction principle, theory of equations, complex numbers, number theory, matrices and determinant to understand their connection with the real-world problems.

Course Learning Outcomes: This course will enable the students to:

i) Employ De Moivre's theorem in a number of applications to solve numerical problems.

ii) Learn about equivalent classes and cardinality of a set.

iii) Use modular arithmetic and basic properties of congruences.

iv) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix.

v) Learn about the solution sets of linear systems using matrix method and Cramer's rule

UNIT-1: Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications. **Marks 10**

[1]: Chapter

UNIT-2: Statements and logic, statements with quantifier, compound statements, implications, proofs in Mathematic; Sets, operations on sets, family of sets, power sets, Cartesian product; Functions, one-one, onto functions and bijections, Composition of functions, Inverse of a function, Image and Inverse image of subsets; Relation, Equivalence relations, Equivalence classes and partitions of a set, congruence modulo n in integers; Induction Principles, the well-ordering principle, greatest common divisor of integers. **Marks 25**

[2] Chapters 1 – 5.

UNIT 3: Systems of Linear Equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, linear independence, introduction to linear transformations, the matrix of a linear transformation; Matrix operations, inverse of a matrix, characterizations of invertible matrices; Determinants, Cramer's rule.

Marks 25

[3]: Chapter 1 (Sections 1.1 – 1.9); Chapter 2 (Sections, 2.1 – 1.3); Chapter 3 (Sections 3.1 – 3.3)

Text Books:

1. TituAndreescu and DorinAndrica, Complex Numbers from A to …. Z, Birkhauser, 2006.

2. A. Kumar, S. Kumaresan and B.K. Sarma, A Foundation Course in Mathematics, Narosa, 2018.

3. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, IndiaReprint, 2007.

Reference Books:

1. S. Barnard and J.M. Child, Higher Algebra, Arihant, 2016.

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

3. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.

HONORS GENERIC ELECTIVE/ REGULA CORE COURSE

14. MATH-HGE-1016A/ MATH-RCC-1016:Calculus

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial Credits**:** 6

Course Objectives: Calculus is referred as 'Mathematics of change' and is concerned with describing the precise way in which changes in one variable relate to the changes in another. Through this course, students can understand the quantitative change in the behaviour of the variables and apply them on the problems related to the environment.

Course Learning Outcomes: The students who take this course will be able to:

i) Understand continuity and differentiability in terms of limits.

ii) Describe asymptotic behavior in terms of limits involving infinity.

iii) Use derivatives to explore the behavior of a given function, locating and classifying its extrema, and graphing the function.

iv) Understand the importance of mean value theorems.

Unit 1: Graphs of simple concrete functions such as polynomial, Trigonometric, Inverse trigonometric ,Exponential and logarithmic functions.

Marks 10

[1] Chapter 1 (Sections 1.1 to 1.3), and Chapter 7 (Sections 7.2, 7.3, and 7.6)

Unit 2: Limits and continuity of a function including approach, Properties of continuous functions including Intermediate value theorem

. **Marks 10**

[2] Chapter 1

Unit 3: Differentiability, Successive differentiation, Leibnitz theorem, Recursion formulae for higher derivatives.

Marks:10

[2] Chapter 3 (Sections 3.2, 3.3, and 3.6), and Exercise 26, page 184.

Unit 4: Rolle's theorem, Lagrange's mean value theorem with geometrical interpretations and simple applications, Taylor's theorem, Taylor's series and Maclaurin's series, Maclaurin's series expansion of functions such as heir use in polynomial approximation and error estimation.

Marks 15

[1] Chapter 4 (Sections 4.2, and 4.3), [2] Chapter 9 (Sections 9.8, and 9.9)

Unit 5: Functions of two or more variables, Graphs and level curves of functions of two variables, Partial differentiation up to second order.

Marks 15

[2] Chapter 13 (Sections 13.1, and 13.3)

Text books:

1. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). *Thomas*' *Calculus* (13thed). Pearson Education, Delhi.Indian Reprint 2017.

2. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore

Pte. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi

15. MATH-HGE-1016B: Analytic Geometry

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial Credits**:** 6

Course Objectives: The primary objective of this course is to introduce the basic tools of two dimensional coordinate systems, general conics, and three dimensional coordinates systems. Also, introduces the vectors in coordinate systems with geometrical properties

Course Learning Outcomes: This course will enable the students to:

i) Transform coordinate systems, conic sections

ii) Learn polar equation of a conic, tangent, normal and related properties

iii) Have a rigorous understanding of the concept of three dimensional coordinate systems

iv) Understand geometrical properties of dot product, cross product of vectors.

UNIT 1: Transformation of coordinates, pair of straight lines. Parabola, parametric coordinates, tangent and normal, ellipse and its conjugate diameters with properties tangent and normal , hyperbola and its asymptotes, tangent and normal, general conics: tangent, condition of tangency, pole and polar, centre of a conic, equation of pair of tangents, reduction to standard forms, central conics, equation of the axes, and length of the axes, polar equation of a conic, tangent and normal and properties.

Marks 30

[1] Chapter 3, 4, 10

UNIT 2: Three-Dimensional Space: Vectors

Rectangular coordinates in 3-space, Spheres and Cylindrical surfaces, Vector viewed geometrically, Vectors in coordinates system, Vectors determine by length and angle, Scalar and vector triple product and their properties, Parametric equations of lines in 2-space and 3-space.

Marks 30

[1] Chapter 11 (11.1, 11.2, 11.3 to 11.5)

Text Books:

1. R. M. Khan, Analytical Geometry of two and three dimension and vector analysis. New Central Book agency 2012.

2. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pte.Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.

Reference Book:

1. E. H. Askwith, The Analytical Geometry of the Conic Sections, Nabu Press (27 February 2012)

2. R. J. T. Bell, Coordinate Solid Geometry, Macmillan, 1983.

3. B. Das, Analytical Geometry of Two and Three Dimension and Vector

NOWGONG COLLEGE (AUTONOMOUS)

B.Sc./B.A Syllabus in Mathematics

Detailed Syllabus

SEMESTER-II

16. MATH-HCC-2016: Real Analysis

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)
Per week: 5 Lectures 1 Tutorial, Credits 6

Course Objectives: The course will develop a deep and rigorous understanding of real line and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. These concepts have wide range of applications in real life scenario.

Course Learning Outcomes: This course will enable the students to:

i) Understand many properties of the real line *R*, including completeness and Archimedean properties.

ii) Learn to define sequences in terms of functions from *N* to a subset of *R*.

iii) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

iv) Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

UNIT 1: Algebraic and order properties of R, absolute value and real line, bounded sets, supremum and infimum, completeness property of R, the Archimedean property, the density theorem, intervals, nested interval theorem, limit point of a set, .Illustration of Bolzano-Weierstrass theorem for sets.

Marks 20

[1] Chapter 2

UNIT-2: Real sequences, bounded sequence, limit of a sequence, convergent sequence, limit theorems, monotone sequences, monotone convergence theorem, subsequences, monotone subsequence theorem, Bolzano Weierstrass theorem for sequences, Cauchy sequences, Cauchy's convergence criterion, properly divergence sequences.

Marks 20

[1] Chapter 3

UNIT 3: Infinite series, convergence and divergence of infinite series, Cauchy criterion, Tests for convergence: comparison test, limit comparison test, ratio test, D' Alembert ratio test, Raabe's test, Gauss test root test, integral test, Absolute convergence, rearrangement theorem, alternating series, Leibniz test, conditional convergence.

Marks 20

[1] Chapter 9 Sections 9.1-3.

Text Book:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons, 2002.

Reference Books:

1. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, *An Introduction to Analysis,* Jones & Bartlett, Second Edition, 2010.

2. A. Kumar and S. Kumaresan, *Basic Course in Real Analysis*, CRC Press, 2014.

3. K. A. Ross, Elementary Analysis: The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

17.MATH-HCC-2026: Differential Equations(including practical)

Total Marks: 100: (Theory 60, Practical 20, Internal assessment 20)

Per week: 4 Lectures 2 Practical, Credits 6(4+2)

Course Objectives: The main objective of this course is to introduce the students to the exciting world of differential equations, mathematical modelling and their applications.

Course Learning Outcomes: The course will enable the students to:

i) Learn basics of differential equations and mathematical modelling.

ii) Formulate differential equations for various mathematical models.

iii) Solve first order non-linear differential equations and linear differential equations of higher order using various techniques.

iv) Apply these techniques to solve and analyze various mathematical models.

UNIT 1: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations, Equation of 1st order but higher degree, Clairut's form.

Marks 20

[2] Chapter 1 (Sections 1.1, and 1.6), [3] Chapter 2, [2] Chapter 1 (Section 1.4, pages 35 to 38), and Chapter 2

(Section 2.3). [3] Chapter 3 (Section 3.3, A and B with Examples 3.8, 3.9)

UNIT 2: Introduction to compartmental model, exponential decay model, exponential growth of population, limited growth of population, limited growth with harvesting.

Marks 20

[1] Chapter 2 (Sections 2.1, 2.5, and 2.6), [1] Chapter 2 (Sections 2.7, and 2.8), [1] Chapter 3 (Sections 3.1 to

3.3)

UNIT 3: General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Marks 20

[2] Chapter 3 (Sections 3.1 to 3.3, Sections 3.4 (pages 172 to 177), and 3.5), [1] Chapter 5 (Sections 5.1, 5.2,

5.4, and 5.9), and Chapter 6 (Sections 6.1 to 6.4)

List of Practical (using any software) **Marks 20**

1. Plotting of first order solution family of differential equation.
2. Plotting of second order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).

Text Books:

1. Barnes, Belinda &Fulford, Glenn R. (2015). *Mathematical Modelling with Case Studies, Using* Maple *and* MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.

2. Edwards, C. Henry, Penney, David E., &Calvis, David T. (2015). *Differential Equation and Boundary Value Problems*: *Computing and Modeling* (5th ed.). Pearson Education.
3. Ross, Shepley L. (2004). *Differential Equations* (3rd ed.). John Wiley & Sons. India

Reference Books:

1. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.
2. Ross, Clay C. (2004). *Differential Equations*: *An Introduction with Mathematica* (2nd ed.). Springer.

GENERIC ELECTIVE PAPERS

18. MATH-HGE-2016A/ MATH-RCC-2016: Algebra

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial Credits:6

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory, matrices, determinant, along with algebraic structures like group, ring and vector space to understand their connection with the real-world problems.

Course Learning Outcomes: This course will enable the students to:

i) Learn how to solve the cubic and biquadratic equations, also learn about symmetric functions of the roots for cubic and biquadratic

ii) Employ De Moivre's theorem in a number of applications to solve numerical problems.

iii) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix. Finding inverse of a matrix with the help of Cayley-Hamilton theorem

iv) Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, ring etc.

v) Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space

Unit 1: Theory of Equations and Expansions of Trigonometric Functions: Fundamental Theorem of Algebra, Relation between roots and coefficients of *n*th degree equation, Remainder and Factor Theorem, Solutions of cubic and biquadratic equations, when some conditions on roots of the equation are given, Symmetric functions of the roots

for cubic and biquadratic; De Moivre'stheorem (both integral and rational index), Solutions of equations using trigonometry and De Moivre's theorem, Expansion for in terms of powers of in terms of cosine and sine of multiples of *x*.

Marks-25

[2] Chapter 3, 4 [3] Chapter 7 (Sections 7.6 and 7.7)

Unit 2: Matrices:

Types of matrices, Rank of a matrix, idea of elementary transformations, Invariance of rank under elementary transformations, Reduction to echelon and normal form and rank, Solutions of linear homogeneous and non homogeneous equations with number of equations and unknowns up to four; Cayley-Hamilton theorem, Characteristic roots and vectors.

Marks-20

[4] Chapter 3 (Sections 3.2, 3.5, and 3.7,Section 3.9)Chapter 2 (Sections 2.1 to 2.5)Chapter 7 (Section 7.1, and Example 7.2.2)

Unit 3: Groups, Rings and Vector Spaces:

Integers modulo *n*, Permutations, Groups, Subgroups, Lagrange's theorem, Euler's theorem, Symmetry Groups of a segment of a line, and regular *n*-gons for $n = 3, 4, 5,$ and 6; Rings and subrings in the context of C[0,1] and Definition and examples of a vector space, Subspace and its properties, Linear independence, Basis and dimension of a vector space

Marks-15

[1] Chapter 1 (Section 1.4), and Chapter 2 (Section 2.3)Chapter 3 (Sections 3.1, and 3.2)(Sections 3.2, 3.3, and 3.6) and Chapter 5 (Section 5.1)

[4] Chapter 4 (Sections 4.1, 4.3, and 4.4)

Text Books:

1. Beachy, John A., & Blair, William D. (2006). *Abstract Algebra* (3rd ed.). Waveland Press, Inc.

2. Burnside, William Snow (1979). *The Theory of Equations*, Vol. 1 (11th ed.) S. Chand & Co. Delhi.Fourth Indian Reprint.
3. Gilbert, William J., & Vanstone, Scott A. (1993). *Classical Algebra* (3rd ed.). Waterloo Mathematics Foundation, Canada.
4. Meyer, Carl D. (2000). *Matrix Analysis and Applied Linear Algebra*. Society for Industrial and Applied Mathematics (Siam).

Reference Books:

1. Dickson, Leonard Eugene (2009). *First Course in The Theory of Equations*. The Project Gutenberg EBook (http://www.gutenberg.org/ebooks/29785)
2. Gilbert, William J. (2004). *Modern Algebra with Applications* (2nd ed.). John Wiley & Sons.
3. S. K. Mappa, Algebra

19. MATH-HGE-2016B: Discrete Mathematics

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial, Credits:6

Course Objectives: The course aims at introducing the concepts of ordered sets, lattices, sub lattices and homomorphisms between lattices. It also includes introduction to modular and distributive lattices along with complemented lattices and Boolean algebra. Then some important applications of Boolean algebra are discussed in switching circuits.

Course Learning outcomes: After the course, the student will be able to:

i) Understand the notion of ordered sets and maps between ordered sets.

ii) Learn about lattices, modular and distributive lattices, sub lattices and homomorphisms between lattices.

iii) Become familiar with Boolean algebra, Boolean homomorphism, Karnaugh diagrams, switching circuits and their applications

Unit 1: Ordered Sets

Definitions, Examples and basic properties of ordered sets, Order isomorphism, Hasse diagrams, Dual of an ordered set, Duality principle, Maximal and minimal elements, Building new ordered sets, Maps between ordered sets.

Marks-20

[1] Chapter 1 (Sections 1.1 to 1.5 and 1.14 to 1.26, and 1.34 to 1.36)

[3] Chapter 1 [Section 1 (1.1 to 1.3)]

Unit 2: Lattices

Lattices as ordered sets, Lattices as algebraic structures, Sub lattices, Products and homomorphisms; Definitions, Examples and properties of modular and distributive lattices, The M3 – N5 Theorem with applications, Complemented lattice, Relatively complemented lattice, Sectionally complemented lattice. homomorphisms.

Marks-20

[1] Chapter 2 (Sections 2.1 to 2.19)Chapter 4 (Sections 4.1 to 4.11)

[3] Chapter 1 [Section 1 (1.5 to 1.20)]Chapter 2 [Section 2 (2.1 to 2.14)]

Unit 3: Boolean Algebras and Switching Circuits

Boolean Algebras, De Morgan's laws, Boolean homomorphism, Representation theorem; Boolean polynomials, Boolean polynomial functions, Disjunctive normal form and conjunctive normal form, BMinimal forms of Boolean polynomial, Quinn-McCluskey method, Karnaugh diagrams, Switching circuits and applications of switching circuits.

Marks-20

[3] Chapter 1 (Sections 3, 4 and 6) Chapter 2 (Sections 7 and 8).

Text Books:

1. Davey, B. A., & Priestley, H. A. (2002). *Introduction to Lattices and Order* (2nd ed.). Cambridge University press, Cambridge.

2. Goodaire, Edgar G., &Parmenter, Michael M. (2011). *Discrete Mathematics with Graph Theory* (3rd ed.). Pearson Education (Singapore) Pvt. Ltd. Indian Reprint.

3. Lidl, Rudolf &Pilz, Gunter. (2004). *Applied Abstract Algebra* (2nd ed.), Undergraduate Texts in Mathematics.Springer (SIE).Indian Reprint.

Reference Books:

1.M. K. Sen& B. C. Chakrabarty: Introduction to Discreate Mathematics, Books and Allied(P) Ltd., Kokkata

NOWGONG COLLEGE (AUTONOMOUS)

B.Sc./B.A Syllabus in Mathematics

Honours Core Course (HCC), Honours Generic Elective (HGE) and Regular Core Course (RCC)

Detailed Syllabus
SEMESTER-III
20. MATH-HCC-3016: Theory of Real Functions

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)
Per week: 5 Lectures 1 Tutorial, Credits-6

Course Objectives: It is a basic course on the study of real valued functions that would develop an analyticalability to have a more matured perspective of the key concepts of calculus, namely; limits, continuity, differentiability and their applications

Course Learning Outcomes: This course will enable the students to:

i) Have a rigorous understanding of the concept of limit of a function.

ii) Learn about continuity and uniform continuity of functions defined on intervals.

iii) Understand geometrical properties of continuous functions on closed and bounded intervals.

iv) Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications.

v) Know about applications of mean value theorems and Taylor's theorem

UNIT 1: Cluster point or limit point of a set, limits of a function (Є approach), sequential criterion for limits, divergence criteria, limit theorems, one sided limits, infinite limits and limits at infinity.

Marks-20

[1] Chapter 4

UNIT 2: Continuous functions, sequential criterion for continuity and discontinuity, algebra of continuous functions, continuous functions on intervals, maximum-minimum theorem, intermediate value theorem, location of roots theorem, preservation of intervals theorem, uniform continuity, uniform continuity theorem, non-uniform continuity criteria.

Marks-20

[1] Chapter 5

UNIT 3: Differentiability of a function at a point and in an interval, Caratheodory's theorem, chain rule, derivative of inverse function, Rolle's theorem, mean value theorem, Darboux's theorem, Cauchy mean value theorem, L'Hospital's rules, Taylor's theorem with reminder terms and applications to inequalities, Taylor's series expansions of exponential and trigonometric functions, ln(1 + x), 1/(ax+b) and $(1x)^n$. **Marks-20**

[1] Chapter 6, and Taylor series as in Section 9.4.

Text Book:

R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2015.

Reference Books:

1. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, Indian Edn. 2014.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. A.Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006.

21. MATH-HCC-3026: Group Theory - I

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week 5 Lectures 1 Tutorial Credits-6

Course Objectives: The objective of the course is to introduce the fundamental theory of groups and their homomorphisms. Symmetric groups and group of symmetries are also studied in detail. Fermat's Little theorem is studied as a consequence of the Lagrange's theorem on finite groups.

Course Learning Outcomes: The course will enable the students to:

i) Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.

ii) Link the fundamental concepts of groups and symmetrical figures.

iii) Analyze the subgroups of cyclic groups and classify subgroups of cyclic groups.

iv) Explain the significance of the notion of coset, normal subgroups and factor groups.

v) Learn about Lagrange's theorem and Fermat's Little theorem.

vi) Know about group homomorphism and group isomorphism.

.**UNIT 1:** Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups. Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. Properties of cyclic groups, classification of subgroups of cyclic groups.

Marks-20

[1]: Chapters 1, Chapter 2, Chapter 3 (including Exercise 20 on page 66 and Exercise 2 on page 86), Chapter 4.

UNIT 2: Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Marks-20

[1]: Chapter 5 (till end of Theorem 5.7), Chapter 7 (till end of Theorem 7.2, including Exercises 6 and 7 on page 168), Chapter 8 (till the end of Example 2), Chapter 9 (till end of Example 10, Theorem 9.3 and 9.5).

UNIT 3: Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

Marks-20

[1]: Chapter 6 (till end of Theorem 6.2), Chapter 10.

Text Book:

1. Gallian, Joseph. A. (2013).*Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited, Delhi. Fourth impression, 2015.

Reference Books:

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

2. G. Santhanam, Algebra, Narosa Publishing House, 2017.

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

4. David S. Dummit and Richard M. Foote, Abstract Algebra (2_{nd}Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2003.

22. MATH-HCC-3036: Analytical Geometry

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures 1 Tutorial Credits 6

Course Objectives: The primary objective of this course is to introduce the basic tools of two dimensional coordinates systems, general conics, and three dimensional coordinate systems.

Course Learning Outcomes: This course will enable the students to:

i) Learn conic sections and transform co-ordinate systems

ii) Learn polar equation of a conic, tangent, normal and properties

iii) Have a rigorous understanding of the concept of three dimensional coordinates systems

.

UNIT 1: Transformation of coordinates, pair of straight lines. Parabola, parametric coordinates, tangent and normal, ellipse and its conjugate diameters with properties, tangent and normal; hyperbola and its asymptotes, tangent and normal; general conics: tangent, condition of tangency, pole and polar, centre of a conic, equation of pair of tangents, reduction to standard forms, central conics, equation of the axes, and length of the axes, polar equation of a conic, tangent and normal and properties.

Marks-30

[1] Chapter 3,4, 10

UNIT 2: Plane, straight lines and shortest distance. Sphere tangent and normal, intersection of two sphere, cone and cylinder, central conicoids, ellipsoid, hyperboloid of one and two sheets, diametral planes, tangent and normal, director sphere, polar plane, section with a given centre, enveloping cone and cylinder . **Marks-30**

[2] Chapters 4,5,6,7 (upto page 125)

Text Books:

1. R. M. Khan, Analytical Geometry of two and three dimension and vector analysis. New Central Book agency 2012.
2. R. J. T. Bell, Coordinate Solid Geometry, Macmillan, 1983.

Reference Book:

1.E. H. Askwith, The Analytical Geometry of the Conic Sections, Nabu Press (27 February 2012)

2.Shanti Narayan: Solid Geometry, S. Chand & Sons, N. Delhi

SKILL ENHANCEMENT COURSE

23. MATH-SEC-3014: Computer Algebra Systems and Related Software

Total marks: 100 (Theory 60, Internal assessment 20, Practical 20)

Purpose of the Course: This course will enable the students to:

i) Use of soft wares; Mathematica/ MATLAB/Maxima etc. as a calculator, for plotting functions and animations

ii) Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigenvectors.

iii) Understand the use of the statistical software **R** as calculator and learn to read and get data into **R.**

iv) Learn the use of **R** in summary calculation, pictorial representation of data and exploring relationship between data.

v) Analyze, test, and interpret technical arguments on the basis of geometry

Unit.1: Brief introduction of compiler & interpreter, data storage in a computer, basic idea of programming languages, Algorithm and Flowchart.

Marks-10

Unit 2: Introduction to CAS and Applications:

Computer Algebra System (CAS), Use of a CAS as a calculator, computing and plotting functions in 2D, plotting functions of two variables using Plot3D and contour plot, plotting parametric curves surfaces, customizing plots, cometing plots, producing tables of values, working with piecewise defined functions, combining graphics.

Marks-25

[1] Chapter 12 (Sections 12.1 to 12.5)

[2] Chapter 1, and Chapter 3 (Sections 3.1 to 3.6, and 3.8) Chapter 6 (Sections 6.2, and 6.3)

Unit 3: Working with Matrices:

Simple programming in a CAS, working with matrices, Gauss elimination method, operations (transpose, determinant, inverse etc.), minors and cofactors, working with large matrices, solving system of linear equations, rank and nullity of a matrix, characteristic polynomials, eigenvalue, eigenvector and diagonalization. **Marks-25**

[2] Chapter 7 (Sections 7.1 to 7.8)

Practical: **Marks-20**

Eight Practical should be done by each student. The teacher can assign practical from the exercises from [1,2].

Text Books:

1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*.CRC Press, Taylor & Francis Group, LLC.

2. Torrence, Bruce F., &Torrence, Eve A. (2009). *The Student's Introduction to Mathematica*: *A Handbook for Precalculus, Calculus, and Linear Algebra* (2nd ed.).Cambridge University Press

GENERIC ELECTIVE PAPERS

24. MATH-HGE-3016A/ MATH-RCC-3016: Differential Equations

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial, Credits: 6

Course Objectives: The main objective of this course is to introduce the students to the exciting world of ordinary differential equations, mathematical modelling and their applications.

Course Learning Outcomes: The course will enable the students to:

i) Learn basics of differential equations and mathematical modelling.

ii) Solve first order non-linear differential equations and linear differential equations of higher order using various techniques.

Unit 1: First Order Ordinary Differential Equations

First order exact differential equations, integrating factors, Rules to find an integrating factor

[1] Chapter 1 (Section 1.1,1.2 1.4), [2] Chapter 1 (Sections 1.1, and 1.2)Chapter 2 (Sections 2.1, and 2.2)

Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties;

Solving differential equation by reducing its order.

Marks-30

[2] Chapter 2 (Sections 2.3, and 2.4), Chapter 3 (Section 3.1), and Chapter 4 (Section 4.1)

Unit 2: Second Order Linear Differential Equations

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation; Simultaneous differential equations.

Marks-30

[1] Chapter 2 (Section 2.2), [2] Chapter 4 (Sections 4.2, 4.3, 4.4, 4.5,4.6) Chapter 7 (Sections 7.1, 7.3)

Text Books:

1. Kreyszig, Erwin (2011). *Advanced Engineering Mathematics* (10th ed.). John Wiley &Sons, Inc. Wiley India Edition 2015.

2. Ross, Shepley L. (1984). *Differential Equations* (3rd ed.). John Wiley & Sons, Inc

25. MATH-HGE-3016B: Linear Programming

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial Credits: 6

Course Objectives: This course develops the ideas underlying the Simplex method. The course covers Linear programming problems with applications to transportation, assignment and game problem. Such problems arise in manufacturing resource planning and financial sectors.

Course Learning Outcomes: This course will enable the students to:

i) Learn about the graphical solution of linear programming problem with two variables.

ii) Learn about the relation between basic feasible solutions and extreme points.

iii) Understand the theory of the simplex method used to solve linear programming problems.

iv) Learn about two-phase and big-M methods to deal with problems involving artificial variables.

v) Learn about the relationships between the primal and dual problems.

vi) Solve transportation and assignment problems.

vii) Apply linear programming method to solve two-person zero-sum game problems.

Unit 1: The Linear Programming Problem**:** Standard, Canonical and matrix forms, Graphical solution. Hyperplanes, Extreme points, Convex and polyhedral sets.Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points.

Marks-20

[1] Chapter 1 (Section 1.1, 1.4 and 1.6)

[2] Chapter 2 (Sections 2.16, 2.19 and 2.20), Chapter 3 (Sections 3,2, 3.4 and 3.10)

Unit 2: Simplex Method**:** Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method.

Marks-20

[1] Chapter 3 (Sections 3.3, 3.6, 3.7 and 3.8

Unit 3: Applications

Transportation Problem: Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving Transportation Problem.

Assignment Problem: Mathematical formulation and Hungarian method of solving.

Marks-20

[3] Chapter 5 (Sections 5.1, 5.3, and 5.4)

[2] Chapter 11 (Sections 11.12, and 11.13)

Text Books:

1. Bazaraa, Mokhtar S., Jarvis, John J. and Sherali, Hanif D. (2010). *Linear Programming and Network Flows* (4th ed.). John Wiley and Sons.

2. Hadley, G. (1997). *Linear Programming*.Narosa Publishing House. New Delhi.

3. Taha, Hamdy A. (2010). *Operations Research*: *An Introduction* (9th ed.). Pearson.

Reference Books:

1. Hillier, Frederick S. & Lieberman, Gerald J. (2015). *Introduction to Operations Research* (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.

2. Thie, Paul R., &Keough, G. E. (2014). *An Introduction to Linear Programming and Game Theory*. (3rded.). Wiley India Pvt. Ltd.

3..KantiSwarup,P K Gupta & Man Mohan: Operation Research, Sultan Sons Ltd.(P), N. Delhi

SEMESTER-IV

26. MATH-HCC-4016: Multivariate Calculus

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 lectures 1 Tutorial, Credits 6

(Use of Scientific calculator is allowed)

Course Objectives: To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding. This course will facilitate to become aware of applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

Course Learning Outcomes: This course will enable the students to:

i) Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.

ii) Understand the maximization and minimization of multivariable functions subject to the given constraints

iii) Learn about inter-relationship amongst the line integral, double and triple integral formulations.

iv) Familiarize with Green's, Stokes' and Gauss divergence theorems

UNIT 1:Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Tangent planes, Total differential and differentiability, Chain rule, Directional derivatives, The gradient, Maximal and normal property of the gradient, Tangent planes and normal lines.

[1] Chapter 11 (Sections 11.1 and 11.2, 11.3 and 11.4,11.5, 11.6)

Marks-15

UNIT 2: Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.

Marks-15

[1] Chapter 11 [Section 11.7 (up to page 605)], Section 11.8 (pages 610-614)], Chapter13 (Section 13.1)

UNIT 3:Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals.

Marks-15

[1] Chapter 12 (Sections 12.1-12.4)

UNIT 4: Line integrals, Applications of line integrals: Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem.

Marks 15

[1] Chapter 12 (Sections 12.5 and 12.6) Chapter 13 (Section 13.2, 13.3), [Sections 13.4 (pages 712 to 716), 13.5 (pages 723 to 726)]

Textbook:

[1] Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). *Calculus* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011

Reference Books:

1. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). *Basic Multivariable Calculus*.Springer (SIE).First Indian Reprint.

2. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.

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

4. Susan Jane Colley, *Vector Calculus*, Pearson: 4th edition, 2011.

27. MATH-HCC-4026: Numerical Methods (including practical)
Total marks: 100: (Theory: 60, Practical 20, Internal Assessment: 20)
Per week: 4 Lectures, 2 Practical, Credits 6(4+2)

Course Objectives: To comprehend various computational techniques to find approximate value for possible root(s) of non-algebraic equations and to find the approximate solutions of system of linear equations and ordinary differential equations. Also, use of Computer Algebra System (CAS) by which the numerical problems can be solved both numerically and analytically, and to enhance the problem solving skills.

Course Learning Outcomes: The course will enable the students to:
i) Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
ii) Know about methods to solve system of linear equations, such as False position method, Fixed point iteration method, Newton's method, Secant method and LU decomposition.
iii) Interpolation techniques to compute the values for a tabulated function at points not in the table.
iv) Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

UNIT 1: Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method for determination of roots of algebraic and transcendental equation:, Gauss elimination LU decomposition method to solve systems of linear algebraic equations..

Marks-20
[1] Chapter 1 (Sections 1.1-1.2), Chapter 2 (Sections 2.1-2.5), Chapter 3 (Section 3.5, 3.8).

UNIT 2: Lagrange and Newton interpolation for linear and higher order.

Marks-15
[1] Chapter 5 (Sections 5.1, 5.3) [2] Chapter 4 (Section 4.3).

UNIT 3: Finite difference operators, Divided difference, Numerical differentiation: forward difference, backward difference and central difference. Integration: trapezoidal rule, Simpson's rule, Euler's method. **Marks-25**
[1]: Chapter 6 (Sections 6.2, 6.4), Chapter 7 (Section 7.2)
Note: Emphasis is to be laid on the algorithms of the above numerical methods.

Practical / Lab work to be performed on a computer: Marks-20

Use of computer aided software (CAS), for example *Matlab / Mathematica / Maple* / *Maxima* etc., for developing the following Numerical programs:
(i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N.
(ii) To find the absolute value of an integer.
(iii) Enter 100 integers into an array and sort them in an ascending order.
(iv) Any two of the following
(a) Bisection Method
(b) Newton Raphson Method
(c) Secant Method
(d) RegulaiFalsi Method
(v) LU decomposition Method
(vi) Gauss-Jacobi Method
(vii) Lagrange Interpolation or Newton Interpolation
(viii) Simpson's rule.

Note: For any of the CAS *Matlab / Mathematica*, 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.

Text Books:

1. B. Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.
2. M. K. Jain, S. R. K. IyengarandR. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, New age International Publisher, India, 5th edition, 2007.

Reference Book:

1. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India,7th edition, 2008.
2. S.S. Sastry, *Introductory Methods of Numerical Analysis*, Prentice-Hall of India, New Delhi, 3rd Ed. 1999.

28. MATH-HCC-4036: Ring Theory

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial,Credits 6

Course Objectives: The objective of this course is to introduce the fundamental theory of rings and their corresponding homomorphisms. Also introduces the basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers.

Courses Learning Outcomes: On completion of this course, the student will be able to:

i) Appreciate the significance of unique factorization in rings and integral domains.

ii) Learn about the fundamental concept of rings, integral domains and fields.

iii) Know about ring homomorphism and isomorphism theorems of rings.

iv) Learn about the polynomial rings over commutative rings, integral domains, Euclidean domains, and UFD

UNIT 1: Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideals, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients.

Marks -30

[1]: Chapter 12, Chapter 13, Chapter 14, Chapter 15.

UNIT 2: Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in Z[x]. Divisibility in integral domains, unique factorization domains, Euclidean domains.

Marks-30

[1]: Chapter 16, Chapter 17, Chapter 18.

Text Books:

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

Reference Books:

1. John B. Fraleigh (2002), A First Course in Abstract Algebra, 7th Ed., Pearson.
2. M. Artin (2011), Abstract Algebra, 2nd Ed., Pearson.
3. D.A.R. Wallace (1998), Groups, Rings and Fields, Springer Verlag London Ltd.
4. G. Santhanam (2017), Algebra, Narosa Publishing House.

SKILL ENHANCEMENT COURSE

SEC-2

29. MATH-SEC-4014: R Programming

Total marks: 100 (Theory 60, Internal assessment 20, Practical 20)

Per week: 2 Lectures 2 Practical, Credits 4(2+2)

Course Objectives: The purpose of this course is to help using R, a powerful free software program for doing statistical computing and graphics. It can be used for exploring and plotting data, as well as performing statistical tests.

Course Learning Outcomes: This course will enable the students to:

i) Become familiar with R syntax and to use R as a calculator.

ii) Understand the concepts of objects, vectors and data types.

iii) Know about summary commands and summary table in R.

iv) Visualize distribution of data in R and learn about normality test.

v) Plot various graphs and charts using R.

Unit 1: Getting Started with R - The Statistical Programming Language

Introducing R, using R as a calculator; Explore data and relationships in R; Reading and getting data into R: combine and scan commands, viewing named objects and removing objects from R, Types and structures ofdata items with their properties, Working with history commands, Saving work in R; Manipulating vectors,Data frames, Matrices and lists; Viewing objects within objects, Constructing data objects and theirconversions. **Marks-15**

[1] Chapter 14 (Sections 14.1 to 14.4), [2] Chapter 2, Chapter 3

Unit 2: Descriptive Statistics and Tabulation

Summary commands: Summary statistics for vectors, Data frames, Matrices and lists; Summary tables. **Marks-15**

[2] Chapter 4

Unit 3: Distribution of Data

Stem and leaf plot, Histograms, Density function and its plotting, The Shapiro-Wilk test for normality, The Kolmogorov-Smirnov test. **Marks-15**

[2] Chapter 5

Unit 4: Graphical Analysis with R

Plotting in R: Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts, Bar charts; Copy and save graphics to other applications. **Marks-15**

[1] Chapter 14 (Section 14.7)[2] Chapter 7

Practical to be done in the Computer Lab using Statistical Software R:

Marks-20

[1] Chapter 14 (Exercises 1 to 3)

[2] Relevant exercises of Chapters 2 to 5, and 7

Note: The practical may be done on the database to be downloaded from https://data.gov.in/

Textbooks:

1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*.CRC Press, Taylor & Francis Group, LLC.

2. Gardener, M. (2012). *Beginning* R: *The Statistical Programming Language*, Wiley Publications.

GENERIC ELECTIVE PAPERS

30. MATH-HGE/RCC-4016: Real Analysis

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial, Credits:6

Course Objectives: The course will develop a deep and rigorous understanding of real line R and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. Course

Course Learning Outcomes: This course will enable the students to:

i) Understand many properties of the real line R, including completeness and Archimedean properties.

ii) Learn to define sequences in terms of functions from R to a subset of R.

iii) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

iv) Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Unit 1: Order completeness of Real numbers, Open and closed sets, Limit of functions, Sequential criterion for limits, Algebra of limits, Properties of continuous functions, Uniform continuity.

Marks- 30

[1] Chapter 2 (Sections 2.1, and 2.2, Sections 2.3, and 2.4)Chapter 11 (Section 11.1, Definition and Examples only)

Unit 2: Sequences, Convergent and Cauchy sequences, Subsequences, Limit superior and limit inferior of a bounded sequence, Monotonically increasing and decreasing sequences, Infinite series andtheir convergences, Positive term series, Comparison tests, Cauchy's nth root test, D' Alembert's ratio test, Raabe's test, Alternating series, Leibnitz test, Absolute and conditional convergence.

Marks -30

[1] Chapter 3, (Sections 3.1, 3.2,3.3,3.4,3.5,3.7), Chapter 9 [Section 9.1(excluding grouping of series)]Sections

9.2 (Statements of tests only), and 9.3 (9.3.1, 9.3.2), Chapter 4 (Sections 4.1 to 4.3).Chapter 5 (Sections 5.1, 5.3, 5.4 excluding continuous extension and approximation)

Text Book:

1. Bartle, Robert G., &Sherbert, Donald R. (2015). *Introduction to Real Analysis* (4th ed.) Wiley India Edition.

Reference Book:

1. Ross, Kenneth A. (2013). *Elementary Analysis*: *The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprint

2. Bilodeau, Gerald G., Thie, Paul R., &Keough, G. E. (2010). *An Introduction to Analysis* (2nd ed.). Jones & Bartlett India Pvt. Ltd. Student Edition.Reprinted 2015.

3. Mathematical Analysis by A.C. Malik and SabitaArrora (?)

SEMESTER-V

31. MATH-HCC-5016: Riemann Integration and Metric spaces

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures 1 Tutorial, Credits 6

Course Objectives: To understand the integration of bounded functions on a closed and bounded interval and its extension to the cases where either the interval of integration is infinite, or the integrand has infinite limits at a finite number of points on the interval of integration. Up to this stage, students do study the concepts of analysis which evidently rely on the notion of distance. In this course, the objective is to develop the usual idea of distance into an abstract form on any set of objects, maintaining its inherent characteristics, and the resulting consequences.

Course Learning Outcomes: The course will enable the students to:

i) Learn about some of the classes and properties of Riemann integrable functions, and the applications of the Fundamental theorems of integration.

ii) Know about improper integrals including, beta and gamma functions.

iii) Learn various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.

iv) Analyse how a theory advances from a particular frame to a general frame.

v) Appreciate the mathematical understanding of various geometrical concepts, viz. Balls or connected sets etc. in an abstract setting.

vi) Know about Banach fixed point theorem, whose far-reaching consequences have resulted into an independent branch of study in analysis, known as fixed point theory.

vii) Learn about the two important topological properties, namely connectedness and compactness of metric spaces.

UNIT-1: Riemann integration: upper and lower sums; Darbouxintegrability, properties of integral, Fundamental theorem of calculus, mean value theorems for integrals, Riemann sum and Riemann integrability, Riemann integrability of monotone and continuous functions on intervals, sum of infinite series as Riemann integrals, Gamma and Beta functions of Improper Integral.

Marks -30

[1] Chapter 6

UNIT 2: Metric spaces: definition and examples, Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, sequences in metric spaces, Cauchy sequences, complete metric spaces, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces.

Marks -15

[2] Chapter 1 Sections 1.1-4, Chapter 2 Sections 2.1, 2.2

UNIT 3: Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity.Homeomorphism, Contraction mappings, Banach contraction mapping principle. Connectedness, connected subsets of R, connectedness and continuous mappings, Idea of compactness.

Marks -15

[2] Chapter 3, Sections 3.1, 3.4, 3.5, 3.7 (up to 3.7.7), Chapter 4 Sections 4.1.

Text Books:

1. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, Indian Edn. 2014.
2. SatishShirali&Harikishan L. Vasudeva, Metric Spaces, Springer Verlag London (2006) (First Indian Reprint 2009)

Reference Books:

1. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
3. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
4. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

32. MATH-HCC-5026: Linear Algebra

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)
Per week: 5 Lectures 1 Tutorial. Credits 6

Course Objectives: The objective of this course is to introduce the fundamental theory of vector spaces, also emphasizes the application of techniques using the adjoint of a linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.
Course Learning Outcomes: The course will enable the students to:
i) Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.
ii) Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.
iii) Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.
iv) Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain orthonormal basis.
v) Find the adjoint, normal, unitary and orthogonal operators.

Unit 1: Vector spaces and subspaces, null space and column space of a matrix, linear transformations, kernel and range, linearly independent sets, bases, coordinate systems, dimension of a vector space, rank, change of basis.

Marks- 30

[1]: Chapter 4 (Sections 4.1 – 4.7)
Unit 2: Eigenvectors and eigenvalues of a matrix, the characteristic equation, diagonalization, eigenvectors of a linear transformation, complex eigenvalues,
[1]: Chapter 4 (Sections 5.1 – 5.5)
Invariant subspaces and Cayley-Hamilton theorem.

Marks-15

[2]: Chapter 5 (Section 5.4)
Unit 3: Inner product, length, and orthogonality, orthogonal sets, orthogonal projections, the Gram–Schmidt process, inner product spaces; Diagonalization of symmetric matrices, the Spectral Theorem.

Marks 15

[1]: Chapter 6 (Sections 6.1 – 6.4, 6.7); Chapter 7 (Section 7.1)
Text Books:
1. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007.
2. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra* (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

Reference Books:
1. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India,1999.
2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
3. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
4. SchaumSeries , Linear Algebra ,Lipchutz

HONOURS DISCIPLIN ESPECIFIC PAPERS/REGULAR DISCIPLIN ESPECIFIC PAPERS HDS/RDS-1

33. MATH-HDS-5016/ MATH-RDS-5016: Linear Programming

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial Credits: 6

Course Objectives: This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear programming with applications to transportation, assignment and game problem. Such problems arise in manufacturing resource planning and financial sectors.

Course Learning Outcomes: This course will enable the students to:
i) Learn about the graphical solution of linear programming problem with two variables.
ii) Learn about the relation between basic feasible solutions and extreme points.
iii) Understand the theory of the simplex method used to solve linear programming problems.
iv) Learn about two-phase and big-M methods to deal with problems involving artificial variables.
v) Learn about the relationships between the primal and dual problems.
vi) Solve transportation and assignment problems.
vii) Apply linear programming method to solve two-person zero-sum game problems.

Unit 1: The Linear Programming Problem**:** Standard, Canonical and matrix forms, Graphical solution. Hyperplanes, Extreme points, Convex and polyhedral sets.Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points. **Marks 15**

[1] Chapter 1 (Section 1.1, 1.4, and 1.6)
[2] Chapter 2 (Sections 2.16, 2.19, and 2.20), and Chapter 3 (Sections 3,2, 3.4, and 3.10)

Unit 2: Simplex Method**:** Optimal solution, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method.

Marks 20

[1] Chapter 3 (Sections 3.3, and 3.6, 3.7, and 3.8)

Unit 3: Motivation and Formulation of Dual problem; Primal-Dual relationships; Fundamental Theorem of Duality; **Marks 10**

[1] Chapter 4 (Sections 4.1 to 4.3)
[1] Chapter 6 (Section 6.1, and 6.2, up to Example 6.4)

Unit 4: Applications
Transportation Problem: Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving Transportation Problem.

Assignment Problem: Mathematical formulation and Hungarian method of solving.
.

Marks 15

[3] Chapter 5 (Sections 5.1, 5.3, and 5.4)
[2] Chapter 11 (Sections 11.12, and 11.13)

Text Books:

1. Bazaraa, Mokhtar S., Jarvis, John J. and Sherali, Hanif. D. (2010).*Linear Programming and Network Flows* (4th ed.). John Wiley and Sons.
2. Hadley, G. (1997). *Linear Programming*.Narosa Publishing House. New Delhi.
3. Taha, Hamdy A. (2010). *Operations Research*: *An Introduction* (9th ed.). Pearson.

Reference Books:

1. Hillier, Frederick S. & Lieberman, Gerald J. (2015). *Introduction to Operations Research* (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.
2. Thie, Paul R., &Keough, G. E. (2014). *An Introduction to Linear Programming and Game Theory*. (3rded.). Wiley India Pvt. Ltd.
3. Shanti Swarup and Monmohan, *Operation Research Model*, S.Chand& Sons.

HDS-2

34. MATH-HDS-5026: Hydromechanics

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures, 1 Tutorial, Credits 6

Course Objectives: The main objectives of this course are to teach students about fluid pressure on plane N surfaces, curved surfaces and Gas law. Also, introduces velocity of a fluid at a point, Eulerian and Lagrangian method, velocity potential and acceleration of a fluid at a point.

Course Learning Outcomes: The course will enable the students to:

i) Know about Pressure equation, rotating fluids.

ii) Learn about Fluid pressure on plane surfaces, resultant pressure on curved surfaces.

iii) Learn about the Eulerian and Lagrangian method.

iv) Learn about equation of continuity, examples, acceleration of a fluid at a point

UNIT 1: Hydrostatics

Pressure equation, condition of equilibrium, lines of force, homogeneous and heterogeneous fluids, elastic fluids, surface of equal pressure, fluid at rest under action of gravity, rotating fluids. Fluid pressure on plane surfaces, centre of pressure, resultant pressure on curved surfaces.

Marks-30

[1] Voll-I Chapter 1-4(related sections only)

UNIT2: Hydrodynamics

Real and ideal fluid, velocity of a fluid at a point, Eulerian and Lagrangian method, stream lines and path lines, steady and unsteady flows, velocity potential, rotational and irrotational motions, material local, convective derivatives, acceleration of a fluid at a point, equation of continuity, examples, Eulers motion of equation. **Marks -30**

[1] Vol-II Chapter 1

Text Book:

1.Besant, W. H., Ramsey, A. S., *A Treatise on Hydromechanics.* (part I & part II), G. Bell And Sons Limited. CBS Publication 1988(Indian print).

2.J.M. Kar*Hydrostatics*, K.P. Basu Publishing 1982, Kolkata.

Reference Books:

1. H. Lamb, *Hydrodynamics*, University Press

2. F. Chorlton, *Fluid dynamics*, CBS Publisher First Edition 1985.

3. M.D. Raisinghania, *Fluid Dynamics*, S. Chand & Sons. 2003.

4. M. Ray, *A Text book of Hydrostatics*, S. Chand & Company. 2000.

SEMESTER-VI

35. MATH-HCC-6016: Complex Analysis (including practical)

Total marks: 100: (Theory: 60, Practical 20, Internal Assessment: 20)

Per week: 4 Lectures, Practical 2, Credits 6(4+2)

Course Objectives: This course aims to introduce the basic ideas of analysis for complex functions with visualization through relevant practical. Emphasis has been given on Cauchy's theorems, series expansions and calculation of residues.

Course Learning Outcomes: Completion of the course will enable the students to:
i) Learn the significance of differentiability of complex functions leading to the understanding of Cauchy−Riemann equations.
ii) Learn some elementary functions and can evaluate the contour integrals.
iii) Understand the role of Cauchy−Goursat theorem and the Cauchy integral formula.
iv) Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.

UNIT 1: Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings, Limits, Limits involving the point at infinity, continuity Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient condition.

Marks 15

[1]: Chapter 1 (Section 11), Chapter 2 (Section 12, 13) Chapter 2 (Sections 15, 16, 17, 18, 19, 20, 21, 22)

UNIT 2: Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions.

Marks 15

[1]: Chapter 2 (Sections 24, 25), Chapter 3 (Sections 29, 30, 34), Chapter 4 (Section 37, 38)

UNIT 3: Definite integrals of functions, Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. **Marks 10**

[1]: Chapter 4 (Section 39, 40, 41, 43)

UNIT 4: Anti derivatives, proof of anti derivative theorem, Cauchy-Goursat theorem, Simply and multiple connected region, Cauchy integral formula. Liouville's theorem and the fundamental theorem of algebra.

[1]: Chapter 4 (Sections 44, 45, 46, 50), Chapter 4 (Sections 51, 52, 53)
Convergence of sequences and series, Taylor series and its examples.Laurent series and its examples, absolute and uniform convergence of power series.
[1]: Chapter 5 (Sections 55, 56, 57, 58, 59, 60, 62, 63, 66)

Marks 20

LAB WORK TO BE PERFORMED ON A COMPUTER:

Marks 20

(MODELING OF THE FOLLOWING PROBLEMS USING MATLAB/ MATHEMATICA/ MAPLE ETC.)

1. Declaring a complex number and graphical representation. e.g. $Z_1 = 3 + 4i$, $Z_2 = 4 - 7i$
2. Program to discuss the algebra of complex numbers, e.g.,
   $Z_1 = 3 + 4i$, $Z_2 = 4 - 7i$, then find $Z_1 + Z_2$, $Z_1 - Z_2$, $Z_1 * Z_2$ and Z_1 / Z_2
3. To find conjugate, modulus and phase angle of an array of complex numbers. e.g.
   $Z = [\ 2+ 3i, 4-2i, 6+11i, 2-5i]$
4. To compute the integral over a straight line path between the two specified end points.

   e. g.,$\oint \mathrm{Sin}z\ dz$, along the contour C which is a straight line path from -1+ i to 2 - i.
5. To perform contour integration., e.g.,
   (i) $\oint(z^2 - 2z + 1)dz$along the Contour C given by $x = y^2 + 1; -2 \le y \le 2$.
   (ii) $\oint(z^3 + 2z^2 + 1)dz$ along the contour C given by $x^2 + y^2 = 1$, which can be
   (iii) parameterized by $x = \cos(t), y = \sin(t)$ for $0 \le y \le 2\pi$.
6. To plot the complex functions and analyze the graph. e.g.,
   (i) $f(z) = z, iz, z^2, z^3, e^z$ and $(z^4-1)^{1/4}$, etc.
7. To perform the Taylor series expansion of a given function f(z) around a given point z. The number of terms that should be used in the Taylor series expansion is given for each function. Hence plot the magnitude of the function and magnitude of its Taylors series expansion, e.g.,
   (i) $f(z) = \exp(z)$ around $z = 0$, $n = 40$ and
   (i) $f(z) = \exp(z^2)$ around $z = 0$, $n = 160$.
8. To determines how many terms should be used in the Taylor series expansion of a given function f(z) around $z = 0$ for a specific value of z to get a percentage error of less than 5%. e.g., for $f(z) = \exp(z)$ around $z = 0$, execute and determine the number of necessary terms to get a percentage error of less than 5 % for the following values of z:
   (i) $z = 30 + 30i$ (ii) $z = 10 + 103\ i$
9. To perform Laurents series expansion of a given function f(z) around a given point z. e.g., (i) $f(z) = (\sin z - 1)/z^4$ around $z = 0$ (ii) $f(z) = \cot(z)/z^4$ around $z = 0$.

Text Book:

1.James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw – Hill International Edition, 2009.

Reference Book:

1.JosephBak and Donald J. Newman, *Complex analysis* (2nd Edition), Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.
2.Schaum Series , *Complex Variable* , Murray R. Spiegel.

36. MATH-HCC-6026: Partial Differential Equations (including practical)

Total marks: 100: (Theory: 60, Practical 20, Internal Assessment: 20)

Per week: 4 Lectures, 2 Practical, Credits 6(4+2)

Course Objectives: The main objectives of this course are to teach students to form and solve partial differential equations and use them in solving some physical problems.

Course Learning Outcomes: The course will enable the students to:

i) Formulate, classify and transform first order PDEs into canonical form.

ii) Learn about method of characteristics and separation of variables to solve first order PDE's.

iii) Classify and solve second order linear PDEs.

iv) Learn about Cauchy problem for second order PDE and homogeneous as well as nonhomogeneous wave equations.

v) Apply the method of separation of variables for solving second order PDEs.

UNIT 1: Introduction, Classification, Construction of first order partial differential equations (PDE). Cauchy's problem for first order equations, linear equations of the first order, Integral surfaces passing through a given curve, Nonlinear partial differential equations of the first order, Cauchy's method of characteristics, Charpit's method. Solutions satisfying given conditions, Jocobi's method.

Marks 30

[1] Chapter 2 (Sections 2.1 to 2.3), [2] Chapter 2 (Section 3, 4,5, 7,8,10,12, 13)

UNIT 2: Canonical form of first order PDE, Method of separation of variables for first order PDE.

Marks 15

[1] Chapter 2 (Sections 2.6 and 2.7)

UNIT 3: Classification of second order PDE, reduction to canonical forms, Equations with constant coefficients, General solution.

Marks 15

[1] Chapter 4 (Sections 4.1 to 4.5), [2] Chapter 3 (Sections 4, 5)

Practical /Lab work to be performed in a Computer Lab:

Marks 20

Modelling of the following similar problems using Mathematica /MATLAB/ Maple/ Maxima/ Scilab etc.

1. Solution of Cauchy problem for first order PDE.
2. Plotting the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.

4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ for any two of the following associated conditions:

(a) $u(x,0) = \phi(x);\ u(x,0) = \psi(x), x \in R; t > 0$

(b) $u(x,0) = \phi(x);\ u_t(x,0) = \psi(x);\ \ u(0,t) = 0, x > 0; t > 0$

(c) $u(x,0) = \phi(x);\ u_t(x,0) = \psi(x);\ \ u_x(0,t) = 0, x > 0; t > 0$

(d) $u(x,0) = \phi(x);\ u_t(x,0) = \psi(x);\ \ u(0,t) = 0, u(l,t) = 0; x > 0; t > 0$

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6. Solution of one-Dimensional heat equation $u_t = k\, u_{xx}$, for a homogeneous rod of length l. That is - solve the IBVP:

$$u_t = k\, u_{xx}, \qquad 0 < x < l, \qquad t > 0$$
$$u(0,t) = 0, \qquad u(l,t) = 0, \qquad t \geq 0$$
$$u(0,t) = f(x), \quad 0 \leq x \leq l$$

Text Book:

1. TynMyint-U and LokenathDebnath, *Linear Partial Differential Equation for Scientists and Engineers*, Springer, Indian reprint, 2006.
2. Sneddon, I. N. (2006). *Elements of Partial Differential Equations*, Dover Publications.Indian Reprint.

Reference Book:

1. Stavroulakis, Ioannis P &Tersian, Stepan A. (2004). *Partial Differential Equations*: *An Introduction with Mathematica and* MAPLE (2nd ed.). World Scientific.
2. M.D. Raisinghania, *Advanced Differential Equations,* S chand&Copany Pvt. Ltd, 2015.

HONOURS DISCIPLINE SPECIFIC PAPERS/REGULAR DISCIPLINE SPECIFIC PAPERS
HDS-3

37. MATH-HDS-6016: Boolean Algebra

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)
Per week 5 Lectures, Tutorial 1, Credits 6,*Each unit carry equal credit*

Course Objectives: This course aims to introduce the basic ideas and properties of ordered sets, Lattices, Boolean algebra and automata theory.
Course Learning Outcomes: The course will enable the students to:
i) Learn about the order isomorphism, Hasse diagrams, building new ordered set.
ii) Learn about the algebraic structure lattices, properties of modular and distributive lattices.
iii) Get ideas about the Boolean algebra, Switching circuits and applications of switching circuits.
iv) Appreciate the theory of automata and its applications

UNIT 1: Ordered Sets: Definitions, Examples and basic properties of ordered sets, Order isomorphism, Hasse diagrams, Dual of an ordered set, Duality principle, Maximal and minimal elements, Building new ordered sets, Maps between ordered sets.

Marks-15

[1] Chapter 1 (Sections 1.1 to 1.5 and 1.14 to 1.26, and 1.34 to 1.36), [3] Chapter 1 [Section 1 (1.1 to 1.3)]

UNIT 2: Lattices: Lattices as ordered sets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, Examples and properties of modular and distributive lattices, The M3 – N5 Theorem with applications, Complemented lattice, Relatively complemented lattice, Sectionally complemented lattice homomorphisms. **Marks-15**
[1] Chapter 2 (Sections 2.1 to 2.19) Chapter 4 (Sections 4.1 to 4.9) (Sections 4.10, and 4.11)
[3] Chapter 1 [Section 1 (1.5 to 1.20)] Chapter 1 [Section 2 (2.1 to 2.6) Chapter 1 [Section 2 (2.7 to 2.14)]

UNIT 3: Boolean Algebras and Switching Circuits
Boolean Algebras, De Morgan's laws, Boolean homomorphism, Representation theorem;
Boolean polynomials, Boolean polynomial functions, Disjunctive normal form and conjunctive normal form, Minimal forms of Boolean polynomial, Quinn-McCluskey method, Karnaugh diagrams, Switching circuits and applications of switching circuits.

Marks-30

[3] Chapter 1 (Sections 3, and 4) Chapter 1 (Section 6) Chapter 2 (Sections 7, and 8).

Text Books:
1. Davey, B. A., & Priestley, H. A. (2002). *Introduction to Lattices and Order* (2nd ed.). Cambridge University press, Cambridge
2. Goodaire, Edgar G. and Parmenter, Michael M. (2011). *Discrete Mathematics with Graph Theory* (3rd ed.). Pearson Education (Singapore) Pvt. Ltd. Indian Reprint.
3. Lidl, Rudolf and Pilz, Gunter. (2004). *Applied Abstract Algebra* (2nd ed.), Undergraduate Texts in Mathematics.Springer (SIE).Indian Reprint.
.
Reference Books:
1. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, *Elements of the Theory of Computation*, 2nd Ed., Prentice-Hall, NJ, 1997.
2. J.A. Anderson, *Automata Theory with Modern Applications*, Cambridge University Press, 2006.
3. M.K. Sen and B.C. Chakraborty, *Introduction to Discrete Mathematics*,

HONOURS DISCIPLINE SPECIFIC PAPERS
(HDS)

38. MATH-HDS-6026: Dissertation/Project Work
Total marks: 100(Work: 80 + Presentation:20)

Each candidate is required to complete any one project work related to any area of the syllabus to be evaluated by internal examiners through viva voce test. The project work will have to be completed according to the following steps –

- Introduction
- Objectives of the study
- Review of related literature
- Significance of the study
- Methodology
- Results/Findings
- Discussion
- Conclusion
- References/Bibliography

RDS-2

39. MATH-RDS-6016: Mechanics

Total marks: 100(Theory: 60+Presentation:20+ Internal Assessment: 20)

Per week: 5 Lectures 1 Tutorial, Credits 6(5+1)

Course Objectives: The course aims at understanding the various concepts of physical quantities and the related effects on different bodies using mathematical techniques. It emphasizes knowledge building for applying mathematics in physical world.

Course Learning Outcomes: The course will enable the students to:

i) Know about the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.

ii) Understand the theory behind friction and center of gravity.

iii) Know about conservation of mechanical energy and work-energy equations.

iv) Learn about translational and rotational motion of rigid bodies.

UNIT 1: Composition and resolution of forces, Parallelogram of forces, Triangle of forces, Converse of triangle of forces, Lami's Theorem, Parallel forces, Moment of a force about a point and an axis. Couple, Resultant of a system of forces.Equilibrium of coplanar forces.Friction, C.G of an arc, plane area, surface of revolution, solid of revolution.

Marks 30

[1] Chapter 1-9 related sections only

UNIT 2: Velocities and acceleration along radial and transverse directions and along tangential and normal directions, motion in a straight line under variable acceleration, simple harmonic motion and elastic string. Newton's law of motion. Work, Energy and momentum, Conservative forces-Potential energy, Impulsive forces, Motion in resisting medium.

Marks 30

[1] Vol-II Chapter I Sections 1.1, 1.2,1.3, Chapter –2 Sections 2.1,2.2, Chapter 3 Sections 3.1.3.2, Chapter 4 Sections 4.1, Chapter 5 Sections 5.1,5.3, Chapter 6 Sections 6.1,6.3.

[2] Chapter 3 (Sections: 3.1, 3.2, 3.3,3.4).

Text Book:

1. S. L. Loney, An *elementary treaties on the Dynamics of particle and of a rigid bodies*, New Age International Pvt. Ltd, 2016.

2. M. Ray and G.C. Sharma, A *Textbook on Dynamics*, S Chand & Sons. 13thed, 2005.

3. Das and Mukherjee, *Statics*, U and Dhur and sons. Publications, Kolkata 14th ed. 2017.

Reference books:

1. A.S. Ramsay, *Statics*, Cambridge University Press, publication year:2009

2. A.S. Ramsay, *Dynamics*, Cambridge University Press, publication year:2009

3. M. R. Spiegel, Theoretical Mechanics, Schuame Series 2010.

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