M. Sc. Mathematics (Semester I to IV)
Choice Based Credit and Grading System
Session W.e.f 2020-2022

1. Program Outcomes(PO's)

Students enrolled in the Master's Programmes offered by the Departments under the Kolhan University will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

PO No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a groups and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

2. Program Specific Outcomes(PSO's)

The post graduates shall be able to realize the following specific outcomes by the end of program studies:
On successful completion of the M.Sc. Mathematics programme a student

Number	Programme Specific Outcomes
PSO-1	Will have a strong foundation in both pure and applied mathematics.
PSO-2	Will be able to apply mathematical skills for solving problems and for preparing various competitive exams
PSO-3	Will be able to communicate mathematical knowledge effectively, in writing as well as orally.
PSO-4	Will identify applications of mathematics in other disciplines, leading to enhancement of career prospects in different fields and research areas.
PSO-5	Will have basic knowledge of programming and computational techniques as required for employment.
PSO-6	Should have the knowledge of the fundamental axioms in mathematics and capability of developing ideas based on them and inculcate mathematical reasoning.
PSO-7	Will be able to locate and analyse the different mathematical texts with appropriate theoretical framework.
PSO-8	Have the knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in science, social science, engineering and technology
PSO-9	Should be able to develop analytical skills, critical thinking, creativity, communication and presentation skills through assignments, seminar, project work.
PSO-10	Should be able to apply their skills and knowledge that translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

3. Postgraduate Attributes (PGA's)

Numbers	**P.G. Attributes**
PGA-1	Disciplinary Knowledge
PGA-2	Creative and Critical Thinking
PGA-3	Reflective Thinking
PGA-4	Problem Solving
PGA-5	Analytical Reasoning
PGA-6	Communication Skills
PGA-7	Research Skills
PGA-8	Life Skills
PGA-9	Life-long Learning
PGA-10	Global Competency

4. SEMESTER-WISE DISTRIBUTION OF COURSES

4.1. M. Sc. (Mathematics) Programme:

Table-1: Course Structure for M. Sc. Programme

Semesters	Courses	Credit	Hrs./Week
I	Core Course-1 (CCMATH101)	4	60
	Core Course-2 (CCMATH102)	4	60
	Core Course-3 (CCMATH103)	4	60
	Core Course-4 (CCMATH104)	4	60
	Core Course-5 (CCMATH105)	4	60
II	Core Course-6 (CCMATH201)	4	60
	Core Course-7 (CCMATH202)	4	60
	Core Course-8 (CCMATH203)	4	60
	Core Course-9 (CCMATH204)	4	60
	Core Course-10 (CCMATH205)	4	60
III	Core Course-11 (CCMATH301)	4	60
	Core Course-12(CCMATH302)	4	60
	Discipline Specific Elective-1 (DSEMATH303)	4	60
	Discipline Specific Elective-2 (DSEMATH304)	4	60
	Project (PR)-1 [PRMATH305]	6	120
IV	Core Course-13 (CCMATH401)	4	60
	Core Course-14 (CCMATH402)	4	60
	Discipline Specific Elective-3 (DSEMATH403)	4	60
	Discipline Specific Elective-4 (DSEMATH404)	4	60
	Project (PR)-2 [PRMATH405]	6	120
Total Credit		**84**	

Note: 1. More credit has been introduced in the upgraded syllabus.
2. New paper has been introduced as per UGC LOCF-2020
3. The Scheme and Syllabus of the course are subject to change according to the UGC guidelines, NEP-2020 and University ordinance.

4.2. Project Work:

The credits for the project(s) may vary from 4 (Four) to 12 (Twelve) depending on the prescription for the contents and the number of hours assigned to the same. Normal projects would carry 6(six) credits with 12 hours per week of time involvement.

4.3. Marks Weightage of a Course:

Each non-practical/non-project course (CC/DSE) shall be of 100 (Hundred) marks having two components;

1. 70 Marks are assigned to the End Semester University Examination (ESUE).
2. 30 Marks are assigned to Sessional Internal Assesment (SIA) conducted by the Department/College.

4.4. Course Content of Mathematics (Under Choice Based Credit System (CBCS))

(Syllabus Scheme for CBCS in M. Sc.)

There will be two Semesters in each year. In third & fourth semesters there are **four Elective papers altogether.** Among **DSEMATH303A**&**DSEMATH303B** only one is to be opted; similarly, among **DSEMATH304A**&**DSEMATH304B** only one is to be opted & among **DSEMATH403A**&**DSEMATH403B** only one is to be opted and finally among **DSEMATH404A**&**DSEMATH404B** only one is to be opted.

1st Semester

1. CCMATH101 100 marks
Real Analysis & Measure Theory

2. CCMATH102 100 marks
Complex Analysis

3. CCMATH103 100 marks
Topology

4. CCMATH104 100 marks
Partial Differential Equation

5. CCMATH105 100 marks
Integral Equation

2nd Semester

6. CCMATH201 100 marks
Group Theory

7. CCMATH202 100 marks
Differential Geometry

8. CCMATH203 100 marks
Tensor Calculus

9. CCMATH204 100 marks
Analytical Dynamics

10. CCMATH205 100 marks
Difference Equation

3rd Semester

11. CCMATH301 100 marks
Discrete mathematics.

12. CCMATH302 100 marks
Functional Analysis.

13. DSEMATH303A 100 marks
Computer Science

Or

14. DSEMATH303B 100 marks
Numerical Methods & Statistics

15. DSEMATH304A 100 marks
Boundary Layer Theory(BLT)

Or

16. DSEMATH304B 100 marks
Operations Research

17. PRMATH305(Project-1) 100 marks

4th Semester

18. CCMATH401 100 marks
Ring & Field

19. CCMATH402 100 marks
Integral Transforms

20. DSEMATH403A 100 marks
Advanced Real Analysis

Or

21. DSEMATH403B 100 marks
Calculus of Variations

22. DSEMATH404A 100 marks
Advanced Set Theory

Or

23. DSEMATH404B 100 marks
Mathematical Modelling

24. PRMATH405(Project-2) 100 marks

5. Learning Outcome Index

5.1. A Mapping of Courses with PSOs

Semester	PSO's ⇨	PSO1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
	Course No. ⇩										
I	1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	3	✓	✓	✓	✓	X	✓	✓	✓	✓	✓
	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II	6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	8	✓	✓	✓	✓	X	✓	✓	✓	✓	✓
	9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
III	11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	13	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	17	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IV	18	✓	✓	✓	✓	X	✓	✓	✓	✓	✓
	19	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	20	✓	✓	✓	✓	X	✓	✓	✓	✓	✓
	21	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	20	✓	✓	✓	✓	X	✓	✓	✓	✓	✓
	23	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	24	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

6.

Syllabus for M. Sc. Mathematics
CBCS Pattern w. e. f. 2020-22

6.1. 1st Semester

CCMATH101 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The course will develop a deep and rigorous understanding of real line $\mathbb{R}$ and of defining terms to prove the results about convergence and divergence of sequences and series of real valued functions. The course will also develop the understanding of basic notions in abstract integration theory and use of Lebesgue integral and its arithmetical properties, comparison with R-integral, bounded convergence theorem, integration theory on topological spaces. These concepts have wide range of applications in real life scenario.

Course Outcomes: After completing this course, student is expected to learn the following:

- Describe fundamental properties of the real numbers that lead to the formal development of real analysis.
- Comprehend rigorous arguments developing the theory underpinning real analysis.
- Demonstrate an understanding of limits and how they are used in sequences, series, differentiation and integration.
- Construct rigorous mathematical proofs of basic results in real analysis.
- Appreciate how abstract ideas and rigorous methods in mathematical analysis can be applied to important practical problems.
- Understand basic notions in abstract integration theory, integration theory on topological spaces.
- Able to use Littlewood's third principle trigonometric Fourier series representation of periodic functions.
- Understand use Lebesgue integral and its arithmetical properties, comparison with R-integral, bounded convergence theorem.

UNIT I: Real Analysis **Lecture-20** **Question-4**

A1: Sequence and series of function: Uniform convergence of sequence and series of real function. Cauchy's general principle of uniform convergence, continuity of the sum of a series of function.Weiestrass's M-test for uniform convergence.Term by term integration and differentiation.

A2: Fourier series: Fourier series expansion of a function relative to an orthonormal system. Bessel's inequality, pointwise convergence of trigonometric Fourier series, Dirichlet's integral, Perseval's theorem, Riemann-Lebesgue theorem, Problems on finding trigonometric Fourier series representation of periodic functions.

UNIT II: Measure Theory **Lecture-20** **Question-4**

B1: Measure theory: Outer measure, measurable sets through Caratheodory approach, arithmetical properties of measurable sets, two fundamental theorems and examples of uncountable sets of zero measure.

B2: Measurable Functions: Closure of class of measurable function under all algebraic and limit operations, Littlewood's third principle trigonometric Fourier series representation of periodic functions. Function bounded over a set of finite measure, condition of measurability, Lebesgue integral and its arithmetical properties, comparison with R-integral, bounded convergence theorem.

REFERENCE BOOKS:

1. Principle of Mathematical Analysis: Walter Rudin
2. Mathematical Analysis: Shanti Narayan
3. Real Analysis: H. L. Royden
4. Advanced Real Analysis: K. K. Jha
5. Measure theory: Gupta & Gupta

CCMATH102 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: In this course students will learn about the algebra and geometry of complex numbers, analyticity, contour integration as well as concepts of theorem like Cauchy's, Morera's, Liouvillies, Taylor's, Laurent's theorem etc. and this course will also develop the understanding about Power series, Residue & poles and conformal mapping.

Course Outcomes: After completing this course, student is expected to learn the following:

- Analyze the concept of differentiability, analyticity, Cauchy-Riemann equations and harmonic functions.
- Compute complex contour integrals for their applications in Cauchy integral theorem.
- Understand the concept of Liouvillies theorem, Rouche's theorem and fundamental theorem of algebra.
- Transform functions into power series, categorize singularities and poles.
- Understand the concept of Taylor's theorem and Laurent's theorem.
- Understand the concept of bilinear transformation and conformal mapping.

Complex Analysis: **Lecture-40** **Question-8**

A1: Integral: Cauchy's integral theorem, Cauchy's integral formula, Morera's theorem, Liouvillies theorem, Taylor's theorem, Laurent's theorem, Rouche's theorem, fundamental theorem of algebra.

A2: Power series: formula for radius of convergence of power series, absolute & uniform convergence theorem of power series, uniqueness theorem of power series, term by term integration and differentiation theorem.

A3; Residue & poles, contour integration and problems

A4: Conformal mapping: Conformal and bilinear mapping, necessary & sufficient condition for conformal mapping, mapping from half plane to circle, mapping from unit circle to unit circle and related problems.

REFERENCE BOOKS:

1. Complex Variable: Churchill
2. Theory of Functions: Titch Marsh
3. Complex Analysis: J. B. Conway
4. Function of a Complex Variable: Goyal & Gupta

CCMATH103 **70 Marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics. It is a central of modern analysis, and many further interesting generalizations of metric space have been developed.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn the compactness in metric space, Ascoli's theorem.
- Understand the concepts Topological spaces and they can apply the definition to construction of topological space and comparison of topologies.
- Understand the concepts of compactness along with Tychonoff's theorem.
- Learn the concepts and properties of the separation and importance of Uryshon's lemma, Tietze extension and Uryshon'smetrization theorem.
- Understand the concepts of Connectedness.

Topology **Lecture-40** **Question-8**

A1: Compactness in metric space, Ascoli's theorem.

A2: Topological spaces: Definition, examples, base, sub-base, first axiom space, second axiom space, comparison of topologies.

A3; Compactness: Compact space, Lindeloff space, product space, Tychonoff's theorem, locally compactness.

A4; Separation: T_1 – space, T_2 – space, normal & completely regular space, Uryshon's lemma, Tietze extension theorem, Uryshon'smetrization theorem.

A5: Connectedness: connectedness & its properties.

REFERENCE BOOKS:

1. Real Analysis: H. L. Royden, P. M. fitzpatrick
2. Topology: J. N. Sharma, J. P. Chauhan
3. Advanced General Topology: K. K. Jha

CCMATH104 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The objective of this course is to introduce partial differential equations (PDE's) as well as ordinary differential equations, fundamental theorems for existence and uniqueness. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations and partial differential equations by using Fourier and Laplace transform. And this course will also develop the understanding about wave equation along with method to solve the boundary value problems using Laplace transformations.

Course Outcomes: After completing this course, student is expected to learn the following:

- Understand to classification of second order partial differential equation and reduction to canonical forms
- Understand the concepts fourier Transformation and apply it solve the PDE's as well as ODE's.
- Derivation of one-dimensional wave equation, D'Alembert's solution of wave equation and application on wave equation.
- Learn the basic of integral transforms and Green's function along with their application to find solution of PDE's.

Partial Differential Equation **Lecture-40** **Question-8**

A1: Classification of second order partial differential equation, reduction to canonical forms

A2: Fourier transform, sin & cosine transform, inverse Fourier transform, application to ordinary & partial differential equation

A3: Wave equation: Derivation and fundamental solution of one-dimensional wave equation in Cartesian form, Application problem, and one-dimensional solution by separation of variables, D'Alembert's solution of wave equation.

A4: Integral transforms and Green's function method of Solution: Solution of PDE using Separation of variables, Fourier transform and by Laplace transform, Green's function and solution of boundary value problems using Laplace transformations.

REFERENCE BOOKS:

1. Partial Differential Equations-L. C. Evans
2. Partial Differential Equations-P. Prasad &R.Ravindran
3. Partial Differential Equations-K. ShankaraRao
4. Advance Engineering Mathematics- E. Kreyszing
5. Use of Integral Transform- I. N. Sneddon

CCMATH105 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: In this course we study in detail about integral equations. Integral equations find numerous applications in real life physical problems. The main objective of the course is to make the learner familiarize with resolvent kernel, successive approximation, solution of homogeneous Fredholm integral equation for solving integral equations and variational problems.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn about the basics of integral equations of first & second kind of Fredholm & Volterra types.
- Find the solutions of by successive substitutions & successive approximations.
- Understand the relation between differential and integral equations, method to solve the equation with separable kernels and intro of calculus of variation.

Integral Equation **Lecture-40** **Question-8**

A1: Integral equations of first & second kind of Fredholm&Volterra Type
A2: Solution by Successive substitutions & successive approximations.
A3: Solution of equation with separable kernels.

REFERENCE BOOKS: -

1. Integral Equations by Shanti Swarup.
2. Integral Equations & their Applications by M. Rahman (WITPress Southampton, BOSTON)

Syllabus for M. Sc. Mathematics
CBCS Pattern w. e. f. 2020-22

6.2. 2nd Semester

CCMATH201 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: This course introduces the basic concepts of modern algebra such as groups like permutation group, direct product and isomorphism and homomorphism of group. This course further explains the group action orbit stabilizer theorem, Sylow theorem & their application. The philosophy of this course is that modern algebraic notions play a fundamental role in mathematics itself and in applications to areas such as physics, computer science, economics and engineering.

Course Outcomes: After completing this course, student is expected to learn the following:

- Explain the fundamental concepts of advanced algebra such as isomorphism and homomorphism of groups, isomorphism theorem.
- Complete knowledge about permutation group & simple group.
- Understand the direct product of a finite number of groups.
- Method for finding class equation of a finite group.
- Learn about group action orbit stabilizer and sylows theorem and application.

Group Theory **Lecture-40** **Question-8**

A1: Isomorphism and homomorphism of groups, isomorphism theorem.
A2: Permutation group & simple group & related topics
A3: Conjugacy classes, normaliser, class equation of a finite group.
A4: Direct products: Direct product of a finite number of groups, necessary & sufficient condition for the isomorphism between the product and the direct product of groups.

A5: Group action orbit stabilizer theorem, Sylow's theorem & application in proving non-simplicity for the isomorphism between the product and the direct product of groups

REFERENCE BOOKS:

1. University Algebra: N. S. Gopala Krishna
2. A First Course in Abstract Algebra: J. B. Fraleigh
3. First Course in Group Theory: P. B. Bhattacharya

CCMATH202 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developable and geodesics.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn about the concepts of curvature, torsion, Serret-Frenet formulae, osculating sphere and spherical curvature and Bertrand curve.
- Familiarize with several concepts of curvilinear co-ordinates on a surface and direction coefficients.
- Understand the concepts of developable surfaces.
- Use the several notions of curvatures such as geodesic curvature and Gaussian curvatures.

Differential Geometry **Lecture-40** **Question-8**

A1: Space curve: Curvature and torsion, Serret-Frenet formulae, helix uniqueness theorem for space curve, the circle of curvature, osculating sphere, locus of centre of curvature, spherical curvature, locus of centre of spherical curvature, Bertrand curve.

A2: Curvilinear co-ordinates on a surface, fundamental magnitudes, direction on a surface.

A3: Curve on a surface: Parametric curves, curvature of normal section, Meusier's theorem, principal direction & principal curvature, line of curvature, theorem of Euler and Dupin, conjugate direction and asymptotic line.

A4: Geodesics: Differential equation of geodesics via normal properties, geodesics on developable, curvature & torsion of a geodesics.

REFERENCE BOOKS:

1. Differential Geometry: C. E. Weatherburn
2. Riemannian Geometry: C. E. Weatherburn
3. Differential Geometry: Gupta, Malik &Pundir (PragatiPrakashan, Meerut)

CCMATH203 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: In this course, we will study the most fundamental knowledge for understanding vectors and tensors were taught in the traditional way. Prior to our applying vector and tensor analysis to research area of modern continuum mechanics, vector and tensor analysis provides a kind of bridge between elementary aspects of linear algebra, geometry and analysis.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn about the concepts of Tensor algebra like contravariant and covariant vector/tensor Kronecker delta etc. and they understand the concept and have learned the basic skills in using vector analysis in solving physics problems.
- Learn about the concepts of covariant differentiation, Ricci's Theorem and they understand the concept and have learned the basic skills in using linear algebra, vector calculus and tensor analysis in solving physics problems.

Tensor Calculus **Lecture-40** **Question-8**

A1; Tensor algebra- contravariant and covariant vector (tensor of first order), tensor of second order (or of rank 2), the Kronecker delta, the tensor of higher rank, invariant or scalars, addition and subtraction of tensor, contraction, product of tensor, inner product symmetric tensor, generalised quotient law, conjugate or reciprocal symmetric tensor, relative tensors, group property of tensor, related problems

A2; Covariant differentiation, The Christoffel three index symbols, transformation of Christoffel symbol, covariant differentiation of vector, covariant differentiation to tensor, laws of covariant differentiation of tensor. divergence & curl of a vector, intrinsic derivative, derived vector, cross product of two vectors, Ricci's Theorem, related problems.

REFERENCE BOOKS:

1. Differential Geometry: C.E. Weatherburn.
2. Riemannian Geometry: C.E. Weatherburn.
3. Tensor Calculus----Schaum’s series
4. Tensor Calculus and Riemannian Geometry: D. C. Agarwal

CCMATH204 **80 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: Introduce students to the concepts of dynamics. The students are expected to develop working skills in the dynamic analysis of both particles and rigid bodies. Master the basics of dynamics, including free body diagrams and kinematics, and broadens those basics through the extensive use of vector math to 3-D problems. Learn the mathematical formulations of dynamics problems.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn about the concepts of motion in two dimensions like motion of C. G. / circular disk on a plane/ sphere on inclined plane when rolling and sliding and develop the kinematics of displacement, velocity and acceleration for systems of particles and rigid bodies.
- Learn about the concepts of motion of rigid body in moving axis like velocity, acceleration etc and they able to apply Euler's geometrical equation in related problems.
- Learn about the concepts of equation of motion and its application in three dimensions.
- Understand the Lagrange's equation of motion of small oscillation.

Analytical Dynamics **Lecture-40** **Question-8**

A1: Motion in two dimensions: Motion of C. G. and motion about C. G., K. E. slipping of road, motion of sphere on inclined plane when rolling and sliding are combined, motion of circular disk on a plane and related problems.

A2: Moving axes: Velocity and acceleration in two-dimensional motion when the axes are moving, velocity and acceleration in three dimensions when the axes are moving, velocity and acceleration in three-dimensional motion in polar form, angular velocity referred to moving axes and Euler's geometrical equation.

A3: Equation of motion and its application in three dimensions: General equation of motion, Euler's equation of motion, momentum of rigid body, moments about instantaneous axes, K. E. of rigid body and related problems.

A4: Lagrange's equation of motion of small oscillation: Generalized co-ordinates, constraints classification of mechanical systems, Lagrange's equation of motion, principle of energy, small oscillation, normal co-ordinates.

REFERENCE BOOKS:

1. Rigid Dynamics: P. P. Gupta & G. S. Malik.
2. Dynamics Part-II: A. S. Ramsay

CCMATH205 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The objective of the course is to present the basic facts of the theory of difference equations and understanding of theoretical and practical methods for solving difference equations and they will be able to compare the differences in the theories of differential and difference equations and, in particular, understand the differences which arise in these theories.

Course Outcomes: After completing this course, student is expected to learn the following:

- Familiarize with dynamics of first order difference equation and learn about the concepts of stair step (cobweb) diagram to solve difference equation and application of cobweb in economics.
- Learn about the concepts of linear difference equation of higher order and several method for finding their solution and understand the application of difference equation in real life problems like propagation of annual plans, gambles ruin national income, the transition of information.

Difference Equation **Lecture-40** **Question-8**

A1; Dynamics of first order difference equation, linear first order difference equation, equilibrium points, their stair step (cobweb) diagram, cobweb theorem of economics, criteria for asymptotic stability of equilibrium points, periodic points and cycles, the equation & bifurcation equilibrium-(fixed) points, 2-cycles, 2_2- cycles.

A2: Linear difference equation of higher order: Difference calculus – the power shift factorial polynomials, anti-difference operator, general theory of linear difference equation, linear homogeneous equation with constant coefficients, linear variation of parameters, limiting behaviour of solution, application – propagation of annual plans, gambles ruin national income, the transition of information.

REFERENCE BOOKS:

1. Introduction to Difference Equation: S. N. Elaydi
2. Difference Equation: An Introduction with Application: Kelly & Peterson
3. Difference Equation: D. C. Agarwal
4. Advanced Difference Equations: M. D. Raisinghania

Syllabus for M. Sc. Mathematics
CBCS Pattern w. e. f. 2020-22

6.3. 3rd Semester

CCMATH301 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The objective of the course is to introduce students with the fundamental concepts in partially ordered sets, lattices, Boolean algebra and graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.

Course Outcomes: After completing this course, student is expected to learn the following:

- Understand the concepts of partially ordered sets, lattices and Hasse diagram.
- Learn the basic concepts of Boolean algebra, lattice, logical gates and relations of Boolean function along with Mathematical Logic: Statement and notations, proposition
- Analyze the basic concepts of graphs, directed graphs, and weighted graphs and able to present a graph by matrices and understand Eulerian and Hamiltonian graphs.
- Learn the use of the Pigeon hole principle.

Discrete mathematics. **Lecture-40** **Question-8**

A1: Partially ordered sets, lattices, geometrical lattices, distributive lattices, modular lattice, complemented lattice.

A2: Logic: Boolean algebra, Boolean expression, application to switching circuits.

A3: Graph theory: Degree sum theorem, Eulerian graph and its properties, Hamiltonian graph, trees, planarity of graphs, Euler's theorem on planar graph and application, chromatic number and five colour theorem, marriage theorem, transversal version of marriage theorem, directed graph, Kruskal's algorithm, Dijkastra's algorithm.

A4: Pigeon hole principle, principle of inclusion & exclusion, derangement.

REFERENCE BOOKS:

1. Lattice: K. K. Jha
2. Discrete Mathematics: K. D. Joshi
3. Automata Theory-Discrete Mathematics: Tremby&Manohar
4. Graph Theory: R. J. Wilson

CCMATH302 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: To familiarize with the basic tools of Functional Analysis involving normed spaces, Banach spaces and Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn about some kind of important inequalities like Cauchy's, Minskowski's and Holder's inequalities. And able to defined normed linear space, Banach space and their quotient space along with subspace.
- Understand the concept of continuous linear maps, $B(N,N^1)$.
- Learn about importance of Hahn-Banach theorem and consequences. And learn about the open mapping theorem and projection on Banach space.
- Learn in details about Hilbert's Space and Schwartz inequalities.

Functional Analysis. **Lecture-40** **Question-8**

A1: Cauchy's, Minskowski's and Holder's inequalities, normed linear space, Banach space, definition and examples including classic Banach space, sub-space and Quotient space.

A2: Continuous linear maps, $B(N,N^1)$: Dual (conjugate) space of 'N', natural embedding theorem, dual of R_n and I_p operator and its conjugate Riesz lemma.

A3: Hahn-Banach theorem and consequences, open mapping theorem and projection on Banach space, closed graph theorem and uniform boundedness principle.

A4: Hilbert's Space: Definition and examples, Schwartz inequalities, orthogonal completeness characterization, Gram-Schmidt orthogonalization.

REFERENCE BOOK:

1. Function Analysis: J, N, Sharma & A. R. Vashishtha
2. Elements of Functional Study: SoboreveLusternic

DSEMATH303A **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The objective of this course is to provide students the complete knowledge of fundamentals of internet like use of browser and website www, E-mail and other internet services and able setup internet in digital devices. Along with complete idea to use of MS WORD and MS POWER POINT for preparing the document and presentations so that they are self prepared for computer work. The curriculum's main objectives are to impart students with an understanding of the basics of computer science.

Course Outcomes: After completing this course, student is expected to learn the following:

- Describe the meaning of internet name and the important terminologies used in internet, identify the activities one can do on-line, get started with Internet, browse the web and explain the application of Internet. use of email and able setup internet in digital devices.
- Learn in details about use of MS WORD for preparing the documentation and knowledge math type.
- Learn in details about use of MS POWER POINT for preparing the presentation for documentation and able apply in every required filed.

Computer Science **Lecture-40** **Question-8**

Unit-1: FUNDAMENTALS OF INTERNET

The Internet and the World Wide Web: Overview: what is Internet, The Internet's history, The Internet's major services, Understanding the world wide web, Using your browser and the world wide web, navigating the web, closing your browser, getting help with your browser, searching the web, search results and web sites. E-mail and other Internet Services: Overview: communicating through the Internet, Using E-mail, Using an E-mail program, Stomping out spam, using web-based e-mail services, More features of the Internet. Connecting to the Internet: Overview: Joining the Internet phenomenon, Connecting to the Internet through wires, How PC applications access the Internet, Connecting to the Internet wirelessly.

Unit 2: MS WORD

Word Basics : Starting word, Creating a new document, Opening preexisting document, The parts of a word window, Typing text, Selecting text, Deleting text, Undo, Redo, Repeat, Inserting text, Replacing text, Formatting text, Cut , Copy, Paste – Formatting Text and Documents : Auto format, Line spacing, Margins, Borders and Shading. Headers and Footers: Definition of headers and footers, creating basic headers and footers, creating different headers and footers for odd and even pages. Tables: Creating a simple table, Creating a table using the table menu, Entering and editing text in a table, selecting in table, adding rows, changing row heights, Deleting rows, Inserting columns, Deleting columns, changing column width. Graphics: Importing graphics, Clipart, Insert picture, Clip Art Gallery, using word's drawing features, drawing objects, text in drawing. Templates: Template types, using templates, exploring templates, modifying templates. Macros: Macro, Record in macros, editing macros, running a macro. Mail Merge: Mail Merge concept, Main document, data

sources, merging data source and main document, Overview of word menu options word basic tool bar.

Unit 3: MS POWER POINT

Basics, Terminology, Getting started, Views: Creating Presentations: Using auto content wizard, Using blank presentation option, Using design template option, Adding slides, Deleting a slide, Importing Images from the outside world, Drawing in power point, Transition and build effects, Deleting a slide, Numbering a slide, Saving presentation, Closing presentation, Printing presentation elements.

REFERENCE BOOK:

1. Peter Norton, Introduction to Computers, sixth Edition, Tata McGraw Hill (2007)
2. Ran Mansfield, working in Microsoft Office, Tata McGraw Hill 2008).

DSEMATH303B **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc. with understanding of various types of measures, various types of probability distributions and testing of hypothesis problems. It aims to equip the students with standard concepts of statistical techniques and their utilization.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn numerical technique to find the solutions of nonlinear equations by using bisection method, False-Position method, Newton-Raphson method, system of linear equations, interpolation problems, numerical differentiations and integration, Initial and boundary value problems.
- Explore the basic ideas about statistical techniques like Probability/Binomial/Poisson's /Normal distribution. And they will learn about regression analysis.

Numerical Methods & Statistics **Lecture-40** **Question-8**

A1: Bisection method, False-Position method, Newton-Raphson method for roots of non-linear equations, Basics Gauss Elimination method, Triangular factorization method for direct solution of system of linear equations, Linear interpolation, Lagrange's & Newton's Interpolation, Spline Interpolation.
A2: Statistical Techniques: Probability distribution, Binomial distribution, Poisson's distribution & Normal distribution. Regression analysis: Lines of regression, properties of Coefficient of regression.

REFERENCE BOOK:

1. Introductory probability & Statistical applications by P.L.Mayer.
2. Numerical Analysis: Lalji Prasad
3. Numerical Analysis: Dutta& Jana
4. Numerical Analysis: Bhupendra Singh

DSEMATH304A **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The course objective is Provide a general review of basic concepts, physics and mathematical descriptions of viscous flow, introduce Navier-Stokes equations and some of the exact solutions and understand the boundary layer model and different analytic methods and introduce flow instability and transition from laminar flow to turbulence and introduce turbulence and modeling and introduce advanced topics in applied fluid mechanics.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn derivation of Navier-Stokes equation of motion for a viscous flow, Poiseuille flow and linearization of the Navier-Stokes equations by method of Stokes and Oseen.
- Understand the boundary layer concept and Reynold's principle of similarity.
- Explore the basic ideas about momentum equation for the boundary layer and its application to the flow past a flat place at zero incidence.

Boundary Layer Theory (BLT) **Lecture-40** **Question-8**

A1. Derivation of Navier-Stokes equation of motion for a viscous flow, Poiseuille flow through a pipe, plane Couette flow, stagnation point, flow between two concentric rotating cylinders, flow near rotating disk, slow motion, limiting case of large small viscosity, linearization of the Navier-Stokes equations by method of Stokes and Oseen.

A2. Boundary layer concept, boundary layer thickness, displacement thickness, derivation of boundary layer equation for flow along a plane and curved wall, Reynold's principle of similarity, similar solutions, boundary layer along a flat plate, a wedge, a circular cylinder and in a convergent channel. A xi-symmetric boundary layer on a body of revolution, boundary layer growth for impulsive start of motion & for uniformly accelerated motion.

A3. The momentum equation for the boundary layer and its application to the flow past a flat place at zero incidence.

REFERENCE BOOK:

1. Boundary Layer Theory: H. Schlichting
2. Modern Development in Fluid Dynamics. Vol-I & II: S. Goldstain
3. Viscous Fluid Dynamics by J L Bansal.

DSEMATH304B **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, project planning and control with PERT-CPM, Integer programming and game theory etc.

Course Outcomes: After completing this course, student is expected to learn the following:

- Understand about inventory like known/probabilistic demand, deterministic model and probabilistic model without lead time.
- Explore the basic ideas about Project planning and control with PERT-CPM .
- Find optimal solution of linear programming model using Game Theory.
- Find optimal solution of Integer programming and Gomory's cutting plane method.

Operations Research **Lecture-40** **Question-8**

A1: Inventory; Known demand, probabilistic demand, deterministic model and probabilistic model without lead time.

A2: Project planning and control with PERT-CPM: Rules of network construction, time calculation in networks, critical path method, PERT, PERT calculations, advantages of network (PERT/CPM), difference between CP and PERT

A3: Game theory: Two-person, zero-sum games, games with mixed strategies, graphical solution, solution by linear programming.

A4: Integer programming: Branch and bound technique, Gomory's cutting plane method.

REFERENCE BOOKS:

1. Operation Research: R. K. Gupta.
2. Introduction to Operation Research: F. S. Hillier & G. L. Lieberman.
3. Operation Research: A. M. Natrajan, P. Balaguruswami, A. Tamilarasi.
4. Operation Research: KantiSwaroop, P. K. Gupta & Man Mohan.
5. Operation Research: S. D. Sharma.
6. Operation Research: Prem Kumar Gupta & D. S. Hira

PRMATH305

Project courses will be of 100 marks and there shall be no internal written examinations. The total hundred marks will have the following three components:

1. Periodical representation – **20 marks**.
2. The written component of the project i.e. project report – **60 marks.**

&

3. Viva voce examination jointly conducted by an external examiner by the university & the internal supervisor/guide – **20 marks.**

Project Work of 100 marks should be related to any topic of the syllabus of 3rd semester. The project work, related to different branches of Mathematics included in semester-III, must be submitted in the form of spiral/hard bound dissertation, typed on one side of the paper containing at least 80 (Eighty) pages and not more than 100 (Hundred) pages.

Course Objective: The main objective of this course is to familiarize students with the skills of planning and writing a research paper, including the formulation of a research problem, the use of primary evidence, and the techniques of documentation. This course presents step-by-step suggestions for writing academic papers that require research from the many sources open to students. It will help them understand the difference between essays and research papers and be familiar with the essential research tools such as bibliographies, indexes, on-line resources, and library catalogs in field of Mathematics.

Course Outcomes: After completing this course, student is expected to learn the following:

- Student's gets exposure to design a research investigation that incorporates appropriate theoretical approaches, conceptual models, and a review of the existing literature.
- Students will learn to structure a discussion in a coherent and convincing way by summarizing the key arguments and providing suitable and coherent findings.
- Student will be able to draw valid conclusions, relating them to the research topic.
- Students will write a comprehensive review of the literature, including a review of other dissertation research related to their study.
- Students develop a design of their study with a discussion of the methodology to be used.
- Students describe how their data will be treated and analyzed of their study.

Syllabus for M. Sc. Mathematics
CBCS Pattern w. e. f. 2020-22

6.4. 4th Semester

CCMATH401 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The main objective of this course is to encourage students to develop a working knowledge of the central ideas of factorization in integral domain like divisibility, GCD & LCM in integral domain and fact about irreducible and prime elements in an integral domain. Here they learn the various types of integral domains, extensions field and its properties as well as Galois Theory and solvability.

Course Outcomes: After completing this course, student is expected to learn the following:

- Learn about Factorization in integral domain and understand the properties of various type of integral domains like UFD, PID and ED and Field.
- Gain the knowledge on the extension fields and understand the concepts of Galois Theory and solvability.

Ring & Field **Lecture-40** **Question-8**

A1: Factorization in integral domain: Concept of divisibility in integral domain, GCD & LCM of two non-zero elements in an integral domain, irreducible and prime elements in an integral domain, relation between prime and irreducible elements, definition and examples of Euclidean domain, principal ideal domain and unique factorization domain, relation between Euclidean domain, principal ideal domain and unique factorization domain, the integral domain Z[I] and K[X] K field properties of Euclidean domain, principal ideal domain and unique

A2: factorization domain, Einstein criteria of irreducibility, Gauss's lemma.

Field theory: Extension of a field, finite extension and infinite extension, algebraic extension and transcendental extension, properties of algebraic extension, relation between algebraic and finite extension, splitting field of a polynomial over a field, normal extension, characterization of finite normal extension, separable extension and properties of a separable extension, perfect field and characterization of perfect field, primitive element theorem, finite field and their existence.

REFERENCE BOOKS:

1. University Algebra: N. S. Gopalakrishna
2. Advanced Course in Modern Algebra: Goyal& Gupta
3. Modern Algebra: M. L. Khanna

CCMATH402 **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The course is designed as an introduction to the theory and applications of integral transforms to problems in linear differential equations, to boundary and initial value problems in partial differential equations and continuum mechanics. Here they will learn about advance integral transform like Stieltjes integrals, Laplace-Stieltjes transform.

Course Outcomes: After completing this course, student is expected to learn the following:

- Know about the Stieltjes integrals, basic properties of Stieltjes integrals and change of variable of indefinite integral.
- Familiarize with The Laplace-Stieltjes transform and they understand region/ abscissa/ absolute/uniform convergence.
- Learn important theorem of Stieltjes/ Laplace and Stieltjes transform.
- Understand about inversion and representation problems for the Laplace transform.

Integral Transforms **Lecture-40** **Question-8**

A1. The Stieltjes integrals: Existence of Stieltjes integrals, properties of Stieltjes integrals, the Stieltjes integral as a series or a Lebesgue integral, normalization, improper Stieltjes integral. laws of the mean, change of variable of indefinite integral, Stieltjes integral as infinite series-second method.

A2. The Laplace-Stieltjes transform: Region of convergence, abscissa of convergence, absolute convergence, uniform convergence.

A3. Abelian theorem for the Laplace and Stieltjes transform, Tauberian theorems, Tauberian theorems for the Stieltjes transform.

A4. Inversion and representation problems for the Laplace transform, Laplace asymptotic of an integral, application to integrals leading to direct inversion formula, general representation theorem.

REFERENCE BOOKS:

1. The Laplace Transform: D. V. Widder
2. The Fourier Transform: I. N. Sneddon

DSEMATH403A **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.**Course**

Objective: The main objective of this course is to familiarize students with $\mathbb{R}^n$ -space and function of several variables also deals with n-dimensional Euclidean space and explore the point set topology in this space. In addition, Partial derivative of higher order, Schwartz theorem, Young's theorem and Taylor's theorem along with implicit function theorem.

Course Outcomes: After completing this course, student is expected to learn the following:

- Know about the n-dimensional Euclidean space and point-sets topology in $\mathbb{R}^n$ like open/closed/compact sets, limit points of sets and also learn about uniform continuity, intermediate value theorem, partial derivatives, directional derivatives and mean value theorem.
- Understand about partial derivative of higher order, Schwartz theorem, Young's theorem and Taylor's theorem.
- Use of Jacobian of transformation and implicit function theorem.

Advanced Real Analysis: **Lecture-40** **Question-8**

$\mathbb{R}^n$-space and function of several variables:

1. n-dimensional Euclidean space, open and closed sets, compact sets, triangular inequality, limit point of a set, Bolzano Weierstrass theorem, Heine-Borel theorem, concept of limit and continuity of a real valued function of several variables and related theorems. Uniform continuity, intermediate value theorem, partial derivatives, directional derivatives and mean value theorem.
2. Partial derivative of higher order, Schwartz theorem, Young's theorem and Taylor's theorem.
3. Jacobian of transformation and implicit function theorem.

REFERENCE BOOK:

1. Advanced Real Analysis by Dr. K. K. Jha (NavbharatPrakashan)
2. Mathematical Analysis by Shanti Nrayan (S Chand & Co.)
3. Real Analysis by H. L. Royden

DSEMATH403B **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Objective: The main objective of the course is to make the learner familiarize with variational Problems with fixed boundaries its many applications in real life physical problems. Here they will learn the variation of a functional and its properties, extremum of functional, sufficient condition for an extremum.

Course Outcomes: After completing this course, student is expected to learn the following:

- Give an account of the foundations of calculus of variations and of its applications in mathematics and physics;
- Formulate important results and theorems covered by the course;
- Use the theory, methods and techniques of the course to solve simpler variation- and boundary value problems. And present mathematical arguments to other

Calculus of Variations: **Lecture-40** **Question-8**

1. Variational Problems with fixed boundaries: Introduction, Variation & its properties, proximity of curves, Linear Functional, Variational problems, Calculus of variation.
2. Fundamental lemma of calculus of variations, Euler's equation (Euler-Lagrange's equation) with related problems, Brachistochrone problem.
3. External of the function, Necessary and sufficient condition for extremavariational methods for boundary value problems in ordinary & partial differential equations.

REFERENCE BOOKS:

1. Advanced ODE and PDE by M. D. Raisinghania
2. Calculus of Variations with Applications by A. S. Gupta

DSEMATH404A **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Objective: The main objective of the course is to make the learner familiarize with set theory in which students will get concept of countability of set which related with all required branches of mathematics and many more theorems related to set. And deal with generalized De-Morgan's laws and related concepts.

Course Outcomes: After completing this course, student is expected to learn the following:

- Know about the countability & cardinality with related theorems and problems.
- Learn important partial & total order relation and familiarize with Zorn's lemma.
- Understand about Generalised De-Morgan's laws and related concepts.

Advanced Set Theory: **Lecture-40** **Question-8**

1. Countability & Cardinality with related theorems, Continuum hypothesis, Cantors theorems Cardinals arithmetic (sum, product & power of cardinal numbers), cardinality of power set of a sets, related problems
2. Partial & total order relation: Partially & totally ordered sets, Lattices, Maximal & minimal elements in a POSET, Zorn's lemma
3. Generalised De-Morgan's laws and related concepts.

REFERENCE BOOKS:

1. Advanced set theory by K. K. Jha
2. Set theory by Lalji Prasad

DSEMATH404B **70 marks**

A total of **EIGHT** questions will be set in which Question No. 1(One) will be Objective Type Question (MCQ/True-False/Fill in the Blanks etc.) consisting 10(Ten) questions of 1(One) mark each and will be COMPULSORY. Any **FOUR** questions shall have to be answered by the examinee out of the remaining **SEVEN** questions carrying 15(Fifteen) marks each.

Course Objective: The main objective of this course is to:

- Enable students understand how mathematical models are formulated, solved and interpreted.
- Make students appreciate the power and limitations of mathematics in solving practical real-life problems.
- Equip students with the basic mathematical modelling skills.

Course Outcomes: After completing this course, student is expected to learn the following:

- Understand what a mathematical model is and explain the series of steps involved in a mathematical modeling process along with types of models and limitations.
- Learn about famous Mathematical Modelling in the Biological environment as well their applications.
- Learn about two species population model here they will explore formulation, solution, interpretation and limitations.
- Learn about Mathematical modeling of epidemics and its basic concept
- Apply the concept of general epidemic model, formulation, solution, interpretation and limitations. Control of an epidemic.

Mathematical Modelling: **Lecture-40** **Question-8**

1. Introduction, Scope of the study, Basic steps of Mathematical Modelling, Its need, Types of Models, Limitations.
2. Mathematical Modelling in the Biological environment: Single species population models, Single logistic models, formulation, solution, interpretation and simultaneous Stochastic Models of population growth.
3. Two species population model: A simple prey predator model, formulation, solution, interpretation and limitations.
4. Mathematical modeling of epidemics: Basic concepts, a simple deterministic model (Simple epidemic model) formulation, solution, interpretation and limitations.
5. General epidemic model, formulation, solution, interpretation and limitations. Control of an epidemic.

REFERENCE BOOKS:

1. Mathematical Modelling by J. N. Kapoor
2. Concept of Mathematical Modelling by W. Meyer (Academic Press, New-York)
3. Mathematics for Dynamic Modelling by E. Beltarmi (Academic Press, Florida)

PRMATH405:

Project courses will be of 100 marks and there shall be no internal written examinations. The total hundred marks will have the following three components:

1. Periodical representation – **20 marks**.

2. The written component of the project i.e. project report – **60 marks.**

&

3. Viva voce examination jointly conducted by an external examiner by the university & the internal supervisor/guide – **20 marks.**

Project Work of 100 marks should be related to any topic of the syllabus of 4th semester. The project work, related to different branches of Mathematics included in semester-IV, must be submitted in the form of spiral/hard bound dissertation, typed on one side of the paper containing at least 80 (Eighty) pages and not more than 100 (Hundred) pages.

Course Objective: The main objective of this course is to familiarize students with the skills of planning and writing a research paper, including the formulation of a research problem, the use of primary evidence, and the techniques of documentation. This course presents step-by-step suggestions for writing academic papers that require research from the many sources open to students. It will help them understand the difference between essays and research papers and be familiar with the essential research tools such as bibliographies, indexes, on-line resources, and library catalogs in field of Mathematics.

Course Outcomes: After completing this course, student is expected to learn the following:

- Student's gets exposure to design a research investigation that incorporates appropriate theoretical approaches, conceptual models, and a review of the existing literature.
- Students will learn to structure a discussion in a coherent and convincing way by summarizing the key arguments and providing suitable and coherent findings.
- Student will be able to draw valid conclusions, relating them to the research topic.
- Students will write a comprehensive review of the literature, including a review of other dissertation research related to their study.
- Students develop a design of their study with a discussion of the methodology to be used.
- Students describe how their data will be treated and analyzed of their study.

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7. Sessional Internal Assessment (SIA) – 30 Marks

The SIA for 30 (Thirty) marks will be conducted by the Department/College for every CC paper & DSE paper. The marks of SIA further break into the following manners.

1. Internal written examination (Subjective/Objective Type)- - 20 Marks
2. Written Assignment - - - - - - 05 Marks
3. Overall performance of student including regularity in class-room lectures/seminars and other activities of the Department/College - - - 05 Marks