DEPARTMENT OF MATHEMATICAL SCIENCES

COURSE STRUCTURE

for

M.Sc. (Mathematics)

Four Semesters (Two Years)

Programme

Based on

Choice Based Credit System (CBCS)
(As per ordinance-14)

I & II Semester 2020-21

III & IV Semester 2021-22

AWADHESH PRATAP SINGH UNIVERSITY, REWA (M.P.)

Semester Course of M.Sc. Mathematics Based on CBCS

Vision of the University:

To be the premier institution that offers teaching and learning programmes of the best quality, graduate students who excel and become leaders in the chosen profession contributing to the community, the nation and the world, and prepares individuals of the highest moral fibre. The vision of university is:

To create an ideal society and an intellectual environment that initiates, nourishes and perpetuates values of co-existence and to fulfil and achieve excellence.

The university, under the dynamic leadership of our honourable Vice-chancellor is working on quite a few ambitious plans. The idea is to develop the university as a knowledge city.

About the Department:

The department came into existence in September 1984 with its initial name 'Department of Mathematics & Statistics'. The foundation stone of the building where the department came into existence was laid down by the then chief minister of Madhya Pradesh Shri Motilal Vora. However, from April 1999, its name has been changed to be known now onwards as the 'Department of Mathematical Sciences'. Initially Prof. R. B. Misra (Professor & Head), Dr. C. K. Sharma (Reader), Dr. N. P. Singh and Dr. J. P. Singh (Lecturers) joined as faculty members in the year 1985. In 1989, Dr. R. N. Singh joined the department as a lecturer. Dr. (Mrs.) Kavita Shrivastava and Dr. Akhileshwar Prasad were appointed as lecturer in the department in years 1994 and 1996 respectively. Prof. R. B. Misra had been the Vice-Chancellor of Avadh University, Faizabad during 1989-92. Prof. C. K. Sharma served as acting Vice-Chancellor of Awadhesh Pratap Singh University, Rewa in the year 2003.

The department runs M.A./M.Sc., M.Phil. and Ph.D. programs in Mathematics. Currently around one hundred fifty students are studying in the department. The department has made notable research contributions in the areas of Special Functions, General Relativity, Cosmology and Differential Geometry. Researchers of the department have been visiting and interacting with various research institutions of the country. The department received library grant from 'National Board for Higher Mathematics, Mumbai'. More than 250 research papers and articles have been published by the faculty of the department in National/International journals. The research papers of the faculty members are also cited in reference books and journals of high impact factor. Four students of the department have qualified NET/SET examination. Since the inception of the department, more than 45 students have been awarded Ph. D. degree and over 250 students have obtained M. Phil. degree.

The department received international recognition in the year 1987 when it was selected under federation scheme of the "International Centre for Theoretical Physics, Trieste (Italy)" Since then the federation was renewed annually till 1992. It provided rare opportunity to the faculty members and students of the department to visit the I.C.T.P. for the improvement of their knowledge with the financial support offered by the Centre. The department successfully organized the 65th Annual Conference of Indian Mathematical Society during Dec. 20-23 1999. Some of the notable personalities who visited the department from time to time are Prof. Franco Fava (Italy), Prof. P. C. Vaidya, Prof. Nand Lal, Prof. B. B. Sinha, Prof. K. K. Azad, Prof. J. B. Rao, Prof. Nand Kishor, Prof. K. P. Singh, Prof. S. R. Roy, Prof. H. C. Khare, Prof. David Gauld (New Zealand), Prof. A. N. Roy, Prof. T. Pati, Prof. Bill Fieldman (U. S. A.), Prof. U. C. De, Prof. M. A. Pathan, Prof. P. N. Pandey and Prof. S. D. Tripathi et al.

The department has organised Invited Talks, Workshops and Seminars to improve the knowledge of students regarding the latest developments in the field of Mathematical Sciences.

Faculty:

1.	Prof. R. N. Singh	Professor and Head
2.	Dr. Shravan K. Pandey	Full Time Faculty
3.	Dr. Anamika Dubey	Full Time Faculty
4.	Dr. Jai Prakash Patel	Full Time Faculty

Aims:

1. Developing the Mathematical Skills among the students and preparing them to take up a career in research.
2. Create more interest in the subject and motivate students for self learning.
3. Strengthening the logical reasoning which is the main ingredient to understand Mathematical concepts.

Objectives:

1. To develop deep understanding of the fundamental axioms/concepts in Mathematics and capability of developing ideas based on them.
2. To encourage students for research studies in Mathematics and related fields.
3. To enable the students being life-long learner who are able to independently expand their mathematical expertise when needed.

Programme: **M.Sc. Mathematics**

Programme Code: **063**

Duration: **4 Semesters (Two Year)**

Number of Seats: **72**

Eligibility:

B.Sc. with Mathematics as a subject.

Age Limit: No age limit.

Admission Procedure:

The admission will be done as per merit of qualifying examinations.

PROGRAMME OUTCOMES (POs)

PO#	PROGRAMMEOUTCOMES
PO1	**Critical Thinking:** Inculcate critical thinking to carry out scientific investigation objectively. Formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development. Critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.
PO2	**Scientific Communication Skills:** Imbibe effective scientific and / or technical communication in both oral and writing. Ability to show the importance of the subject as precursor to various scientific developments since the beginning of the civilization.
PO3	**Social Interaction:** Elicit views of others, mediate disagreements and help reach conclusions in group settings.
PO4	**Enlightened Citizenship:** Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges.
PO5	**Ethics:** Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in the subject concerned. Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adoptive objective, unbiased and truthful actions in all aspects.
PO6	**Environment and Sustainability:** Understand the issues of environmental contexts and sustainable development.
PO7	**Lifelong Learning:** Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning throughout life, through self- paced and self- directed learning aimed at personal development, and adapting to changing academic demands of work place through knowledge/ skill development/ reskilling.

PROGRAMME SPECIFICOUT COMES (PSOs) (M.Sc. Mathematics)

PSO #	PROGRAMME SPECIFIC OUTCOMES
PSO1	**Strong Foundation in Knowledge:** Have strong foundation in core areas of Mathematics and able to communicate Mathematics effectively.
PSO2	**Problem Solving:** Solve complex problems by critical understanding, analysis and synthesis, Evaluate hypotheses, theories, methods and evidence within their proper contexts.
PSO3	**Application and Research Efficiency:** Provide a systematic understanding of the concepts and theories of mathematics and their application in the real world- to an advanced level, and enhance career prospects in a huge array of fields, viz. in industry, commerce, education, finance and research.
PSO4	**Lifelong Practical Knowledge:** Recognize the need to engage in lifelong learning through continuous education and research leading to higher degrees like Ph.D., D.Sc. etc.

COURSE STRUCTURE FOR M.SC. MATHEMATICS AT A GLANCE

Semester-I

Core Courses								
S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
1.	MAT-C101	Advanced Abstract Algebra-I	4	60	40	100	21	14
2.	MAT-C102	Real Analysis	4	60	40	100	21	14
3.	MAT-C103	Topology-I	4	60	40	100	21	14
4.	MAT-C104	Complex Analysis	4	60	40	100	21	14
		Total Core Credits	**16**	**240**	**160**	**400**	**-**	**-**
Generic Elective (Any one of the following)								
5.	MAT-GE105	Tensor Analysis	4	60	40	100	21	14
6.	MAT-GE106	Linear Programming Problems	4	60	40	100	21	14
7.	MAT-GE107	Computational Mathematics	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
8.	MAT-C108	Comprehensive Viva-Voce	4	-	-	100	35	-
		Total (Core+ Generic Elective + Comprehensive Viva)	**24**	**300**	**200**	**600**	**-**	**-**

Semester-II

Core Courses								
S.No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
1.	MAT-C201	Advanced Abstract Algebra-II	4	60	40	100	21	14
2.	MAT-C202	Lebesgue Measure and Integration	4	60	40	100	21	14
3.	MAT-C203	Topology-II	4	60	40	100	21	14
4.	MAT-C204	Differential Geometry	4	60	40	100	21	14
		Total Core Credits	**16**	**240**	**160**	**400**	**-**	**-**
Generic Elective (Any one of the following)								
5.	MAT-GE205	Number Theory	4	60	40	100	21	14
6.	MAT-GE206	Wavelet Analysis	4	60	40	100	21	14
7.	MAT-GE207	Quantitative Techniques	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
8.	MAT-C208	Comprehensive Viva-Voce	4	-	-	100	35	-
		Total (Core+ Generic Elective + Comprehensive Viva)	**24**	**300**	**200**	**600**	**-**	**-**

Semester-III

S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
Core Courses								
1.	MAT-C301	Functional Analysis-I	4	60	40	100	21	14
2.	MAT-C302	Advanced Special Functions-I	4	60	40	100	21	14
3.	MAT-C303	Riemannian Geometry-I	4	60	40	100	21	14
		Total Core Credits	**12**	**180**	**120**	**300**	**-**	**-**
Discipline Centric Elective (Any one of the following)								
4.	MAT-DCE304	Integral Transforms-I	4	60	40	100	21	14
5.	MAT-DCE305	Differential Geometry of Manifolds-I	4	60	40	100	21	14
6.	MAT-DCE306	General Theory of Relativity and Cosmology –I	4	60	40	100	21	14
		Total Discipline Centric Elective Credits	**4**	**60**	**40**	**100**	**-**	**-**
Generic Elective (Any one of the following)								
7.	MAT-GE307	Operations Research-I	4	60	40	100	21	14
8.	MAT-GE308	Advanced Discrete Mathematics-I	4	60	40	100	21	14
9.	MAT-GE309	Bio-Mathematics	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C310	Comprehensive Viva-Voce	4	-	-	100	35	-
		Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)	**12+4+ 4+4= 24**	**300**	**200**	**500 +100 =600**	**-**	**-**

Semester-IV

S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
Core Courses								
1.	MAT-C401	Functional Analysis-II	4	60	40	100	21	14
2.	MAT-C402	Advanced Special Functions-II	4	60	40	100	21	14
3.	MAT-C403	Riemannian Geometry-II	4	60	40	100	21	14
		Total Core Credits	**12**	**180**	**120**	**300**	**-**	**-**
Discipline Centric Elective (Any one of the following)								
4.	MAT-DCE404	Integral Transforms-II	4	60	40	100	21	14
5.	MAT-DCE405	Differential Geometry of Manifolds-II	4	60	40	100	21	14
6.	MAT-DCE406	General Theory of Relativity and Cosmology –II	4	60	40	100	21	14
		Total Discipline Centric Elective Credits	**4**	**60**	**40**	**100**	**-**	**-**

Generic Elective (Any one of the following)								
7.	MAT-GE407	Operations Research-II	4	60	40	100	21	14
8.	MAT-GE408	Advanced Discrete Mathematics-II	4	60	40	100	21	14
9.	MAT-GE409	Cryptography	4	60	40	100	21	14
Total Generic Elective Credit			**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C410	Comprehensive Viva-Voce	4	-	-	100	35	-
	Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)		**12+4+ 4+4= 24**	**300**	**200**	**500 +100 =600**	**-**	**-**
	Total Semester (I+II+III+IV)		**96**	**1200**	**800**	**2400**		

Programme Administration

Evaluation:

1. Each course will be assessed for 100 marks, out of which 60 marks will be for end-semester examination and 40 marks will be for Continuous Evaluation. The duration of end-semester examination for each course shall be of three hours.
2. The question paper of end-semester examination of each course will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.
3. During the semester, a teacher offering the course will do the continuous evaluation of the student at three points of time by conducting three tests of 20 marks each. Of these, two must be written tests and third may be written test/Quiz/Seminar/Assignment. Marks obtained in two best tests out of three will be awarded to the student.
4. Total of Marks obtained in end-semester examination and best two tests under continuous evaluation will decide the grade in the course.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-I

Core Courses								
S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
1.	MAT-C101	Advanced Abstract Algebra-I	4	60	40	100	21	14
2.	MAT-C102	Real Analysis	4	60	40	100	21	14
3.	MAT-C103	Topology-I	4	60	40	100	21	14
4.	MAT-C104	Complex Analysis	4	60	40	100	21	14
		Total Core Credits	**16**	**240**	**160**	**400**	**-**	**-**
Generic Elective (Any one of the following)								
5.	MAT-GE105	Tensor Analysis	4	60	40	100	21	14
6.	MAT-GE106	Linear Programming Problems	4	60	40	100	21	14
7.	MAT-GE107	Computational Mathematics	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
8.	MAT-C108	Comprehensive Viva-Voce	4	-	-	100	35	-
		Total (Core+ Generic Elective + Comprehensive Viva)	**24**	**300**	**200**	**600**	**-**	**-**

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-I

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-C101 Advanced Abstract Algebra – I

Course Objectives: The objective of this course is to study the concepts of Normal series, Composition series, Zessenhaus lemma, Solvable groups, Nilpotent groups and fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Normal and Subnormal series of groups, Composition series, Zessenhaus lemma, Schreier's theorem, Jordan-Hölder theorem.

Unit 2-

Solvable and Nilpotent groups.

Unit 3-

Extension fields, Roots of polynomials, Algebraic and transcendental extensions, Splitting fields, Separable and inseparable extensions.

Unit 4-

Perfect fields, Finite fields, Primitive elements, Algebraically closed fields.

Unit 5-

Automorphism of extensions, Galois extensions, Fundamental theorem of Galois theory, Solution of polynomial equations by radicals, Insolvability of general equation of degree 5 by radicals.

Recommended Books:

[1] I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd. New Delhi, 1975.
[2] Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
[3] P.B. Bhattacharya, S.K.Jain and S.R.Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.

Reference Books:

[1] N. Jacobson, Basic Algebra, Vols. I & II, W.H. Freeman, 1980(also published by Hindustan Publishing Company).
[2] S. Lang, Algebra, Addison-Wesley.
[3] I.S. Luther and I.B.S. Passi, Algebra, Vol.I-Groups, Vol. II-Rings, Narosa Publishing House (V0l. I-1996, Vol. II- 1999).

Course Learning Outcomes: After studying this work student will be able to:

CO1: Understand the proof of Schreier's theorem and Jordan-Holder theorem and also able to prove fundamental theorem of arithmetic using Jordan-Holder theorem.

CO2: Able to discuss Solvable and Nilpotent groups.

CO3: Characterize perfect fields using separable extensions and the proof of fundamental theorem of Galois theory.

CO4: Classify finite fields using roots of unity and understand Galois theory.

CO5: Apply Galois theory of equations to prove that a polynomial equation over a field of characteristic is solvable by radicals iff its group (Galois) is a solvable group.

M.Sc. MATHEMATICS (Under CBCS)

SEMESTER-I

Course Code: MAT-C102 Real Analysis

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The main objective of this course is to study the concepts of Riemann-Stieltjes integral, Integration of vector valued functions, Sequence and series of functions, Functions of several variables, Inverse function theorem and Implicit function theorem and to prepare students for further research in analysis and differential geometry.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Definition and existence of Riemann-Stieltjes integral and its properties, Integration and differentiation, The fundamental theorem of calculus.

Unit 2-

Integration of vector-valued functions, Rectifiable curves, Rearrangement of terms of series, Riemann's theorem.

Unit 3-

Sequence and series of functions, Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's test for uniform convergence and continuity, Uniform convergence and Riemann-Stieltjes integration , Uniform convergence and differentiation, Weierstrass approximation theorem, Power series, Uniqueness theorem for power series, Abel's and Tauber's theorems.

Unit 4-

Functions of several variables, Linear transformations, Derivatives in an open subset of R^n, Chain rule, Partial derivatives, Interchange of the order of differentiation, Derivatives of higher orders, Taylor's theorem, Inverse function theorem.

Unit 5-

Implicit function theorem, Jacobians, Extremum problems with constraints, Lagrange's multiplier method, Differentiation of integrals, Partitions of unity, Differential forms, Stoke's theorem.

Recommended Books:

[1] Walter Rudin, Principles of Mathematical Analysis (3rd Edition), McGraw-Hill, Kogakusha, 1976, International Student Edition.

Reference Books:

[1] T.M.Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
[2] H.L. Royden, Real Analysis, Macmillan Publishing Co. Inc., 4th Edition, New York, 1993.

Course Learning Outcomes: After studying this work student will be able to:

CO1: Describe the Riemann-Stieltjes integral and its properties and learns the fundamental theorem of calculus.

CO2: Understand the theory of sequence and series of functions, Pointwise and uniform convergence, Power series.

CO3: Able to describe functions of several variables.

CO4: Understand and evaluate Inverse function theorem and implicit function theorem.

CO5: Able to apply Partitions of unity, Differential forms, Stoke's theorem.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-I
Course Code: MAT-C103 Topology-I

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: Topology is concerned with the properties of geometric objects that are preserved under continuous deformations such as stretching, twisting, crumpling and bending but not tearing and gluing. The objective of this course is to study cardinal numbers, Zorn's lemma, Well-Ordering theorem, definition and examples of topological spaces, Neighbourhood systems, Continuous functions and Homeomorphism, First and second countable spaces, Separable spaces, Connected spaces and Path connectedness.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Countable and uncountable sets, Infinite sets and the axiom of choice, Cardinal numbers and its arithmetic. Schroeder-Bernstein theorem, Cantor's theorem and the continuum hypothesis, Zorn's lemma, Well-ordering theorem.

Unit 2-

Definition and examples of topological spaces, Closed sets, Neighbourhoods, Closure, Dense sets, Interior, Exterior and boundary, Accumulation points and derived sets, Bases and sub-bases, Subspaces and relative topology.

Unit 3-

Alternate methods of defining a topology in terms of Kuratowski closure operator and Neighbourhood systems, Continuous functions and homeomorphism.

Unit 4-

First and second countable spaces, Separable spaces, Second countability and Separability.

Unit 5-

Connected spaces, Connectedness on real line, Components, Locally connected spaces, Path-connectedness.

Recommended Books:

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

Reference Books:

[1] K.D.Joshi, Introduction to General Topology, Willey Eastern Limited, 1983.
[2] G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.
[3] J.Dugundji, Topology, Allyn and Bacon, 1966(Reprinted in India by Prentice-Hall of India Pvt. Ltd.).
[4] N. Bourbaki, General Topology Part-I (Transl.) Addition Wesley Reading 1966.

Course Learning Outcomes: After studying this work student will be able to:

CO1: distinguish countable and uncountable sets.

CO2: Understand Topological spaces and evaluate Neighbourhoods, Closure, Dense sets, Interior, Exterior and boundary, Accumulation points and derived sets, Bases and sub-bases.

CO3: Understand Continuous functions and homeomorphism

CO4: Able to distinguish First and second countable spaces, Understand Separable spaces, Second countability and Separability.

CO5: Understand the definition and basic properties of connected spaces, Path connectedness.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-I
Course Code: MAT-C104 Complex Analysis

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The course aims to familiarize the learner with complex function theory, analytic functions theory, the concept of index and Cauchy's theorems, integral formulas, singularities and contour integrations and finally provide a glimpse of maximum principle and Schwarz' lemma.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Complex Integration, Cauchy-Goursat theorem, Cauchy integral formula, Higher order derivatives.

Unit 2-

Morera's theorem, Cauchy's inequality, Liouville's theorem, The fundamental theorem of algebra, Taylor's theorem.

Unit 3-

The maximum modulus principle, Schwartz lemma, Laurent's series, Singularities, Meromorphic functions, The argument principle, Rouche's theorem, Inverse function theorem.

Unit 4-

Residues, Cauchy's residue theorem, Evaluation of integrals, Branches of many valued functions with special reference to arg z, log z, z^a.

Unit 5-

Conformal Mappings, Mobius (Bilinear) Transformations involving circles and half-planes, Fixed point, Cross ratio, Transformations $w = z^2$, $w = \tan^2(z/2)$. Power Series and its Convergence.

Recommended Books:
[1] J.B. Conway, Functions of One Complex Variable, Springer-Verlag, International Student Edition, Narosa Publishing House,1980.

Reference Books:
[1] S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House,1997.
[2] L.V. Ahlfors, Complex Analysis, McGraw-Hill, 1979.
[3] J.W.Brown and R.V.Churchill, Complex Variables and Applications, 2004.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Complex integration, Cauchy's theorems and integral formulas on open subsets of the plane.

CO2: Able to understand Morera's theorem as converse of Cauchy's theoerem.

CO3: Understand the kind of singularities of a meromorphic functions which helps in residue theory and contour integrations.

CO4: Able to deduce Residues, and to apply Cauchy's residue theorem, Evaluation of integrals.

CO5: Understand Conformal Mappings, Mobius (Bilinear) Transformations involving circles and half-planes, Fixed point, Cross ratio, Power Series and its Convergence.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-I

Generic Elective (Any one of the following)								
S. No.	**Course Code**	**Title of the Course**	**Credit**	**Maximum Marks**		**Total**	**Minimum Pass Marks**	
				Theory	**Cont. Evln.**		**Theory**	**Cont. Evln.**
5.	MAT-GE105	Tensor Analysis	4	60	40	100	21	14
6.	MAT-GE106	Linear Programming Problems	4	60	40	100	21	14
7.	MAT-GE107	Computational Mathematics	4	60	40	100	21	14
Total Generic Elective Credit			**4**	**60**	**40**	**100**	**-**	**-**
8.	MAT-C108	Comprehensive Viva-Voce	4	-	-	100	35	-
	Total (Core+ Generic Elective + Comprehensive Viva)		**24**	**300**	**200**	**600**	**-**	**-**

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-I
Course Code: MAT-GE105 Tensor Analysis

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: Tensors have their applications to Riemannian Geometry, Mechanics, Elasticity, Theory of Relativity, Electromagnetic Theory and many other disciplines of Science and Engineering. The aim of this course is to study fundamental concepts of tensor and tensor analysis.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Coordinate systems and their transformation laws, Kronecker deltas, Contravariant and Covariant vectors and tensors, Mixed tensors, Algebra of tensors, Quotient law.

Unit 2-

Symmetric and Skew-symmetric tensors, Contraction and transvection of tensors, Metric tensor and its associated tensor.

Unit 3-

Christoffel symbols and their coordinate transformation laws.

Unit 4-

Covariant derivatives, Gradient, Divergence and Curl.

Unit 5-

Intrinsic derivative, Levi-Civita concept of parallelism, Curvature tensor.

Recommended Books:

[1] R.S. Mishra, A course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad,1965.
[2] B.B.Sinha, Differential Geometry-An Introduction, Shyam Prakashan Mandir, Allahabad, 1978.

Reference Books:

[1] C.E.Weatherburn, An Introduction to Tensor Calculus and Riemannian Geometry, Cambridge University Press, London, 1942 and Radha Publishing House Calcutta, Indian Edition, 1995.
[2] T.J.Willmore, Differential Geometry, Oxford University Press, London, 1959 and Indian XI Edition, New Delhi, 1993.
[3] L.P. Eisenhart, Differential Geometry with the use of Tensors, Princeton University Press, New Jersey, 1949.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand coordinate systems and their transformation laws, concepts of tensors and their types, Quotient law.

CO2: Able to differ between tensor quantities and scalar or vector quantities.

CO3: Understand Contraction and transvection of tensors, Metric tensor and its associated tensor, Christoffel symbols and their coordinate transformation laws.

CO4: Able to handle Covariant derivatives, Gradient, Divergence and Curl.

CO5: Understand Intrinsic derivative, Levi-Civita concept of parallelism, Curvature tensor.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-I

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-GE106 Linear Programming Problems

Course Objectives: The objective of Linear programming problems is to introduce students to use quantitative methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit-I:

Linear Programming Problems, Formulation of the Linear Programming Problems, Graphical solution of LP Problems, Lines and Hyperplanes, Convex set, Extreme points of a convex set, Convex combination, Convex Hull, Convex Polyhedron, Fundamental theorem of Linear Programming, Trial and Error method.

Unit-II:

General Linear Programming Problem, Simplex method, Artificial variable technique, Two phase method, Big-M method, Problem of degeneracy, Method to resolve degeneracy.

Unit-III:

Duality in Linear Programming, Fundamental theorem of duality and theorems of duality, Dual simplex method.

Unit-IV:

Assignment Problem : Mathematical formulation of Assignment Problem, Solution of Assignment Problem, Unbalanced assignment problem, Sensitivity in assignment problems, The Traveling-Salesman Problem, Formulation of Traveling -Salesman Problem as an assignment problem and solution procedure.

Unit-V:

Transportation Problem : Mathematical Formulation of Transportation Problem, Initial Basic Feasible Solution : North-West Corner Rule, Lowest-Cost Entry Method, Vogel's Approximation Method, Optimality Test by MODI Method, Stepping Stone Method, Degeneracy in Transportation Problem.

Recommended Books:

[1] Kanti Swarup, P. K. Gupta and Manmohan, Operations Research, Sultan Chand & Sons, New Delhi.

Reference Books:

[1] S. D. Sharma, Operations Research, Kedar Nath Ram Nath & Co., 1996.
[2] F. S. Hillaer and G. J. Lieberman, Industrial Engineering Series, 1995.
[3] G. Hadley, Linear Programming, Narosa Publishing House, 1995.
[4] H. A. Taha, Operations Research-An Introduction, Macmillan Publishing Co. Inc. New York.
[5] P. K. Gupta and D. S. Hira, Operations Research-An Introduction, S. Chand & Sons, New Delhi.
[6] N. S. Kambo, Mathematical Programming Technique, Affiliated East West Pvt. Ltd.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Able to understand Linear programming problem and to formulate some real-life problems into Linear programming problem.

CO2: Understand the simplex method to find an optimal vector for the standard linear programming problem and the corresponding dual problem.

CO3: Understand Duality in Linear Programming, Fundamental theorem of duality and Dual simplex method.

CO4: Understand Assignment Problems and able to obtain optimum solution of Assignment problems.

CO5: Understand Transportation Problems and able to obtain optimum solution of Transportation problems. Able to distinguish Transportation and Assignment problems.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-I

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-GE107 Computational Mathematics

Course Objectives: The course is framed to extend the students knowledge about understanding numerical techniques, to solve various categories of problems. This course will also help in developing deep understanding of the approximation techniques and problem solving capabilities.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Binary Systems: Digital Systems, Binary numbers, Binary Codes, Error detecting code, Computer arithmetic number base conversions, Octal and Hexadecimal conversions.

Unit 2-

Errors and approximation: Representation of integers and fractions, fixed point and floating point arithmetic, error propagation, loss of significance, condition and instability, computational method of error propagation.

Unit 3-

Solution of Non-linear equations, iterative methods of 2nd degree, Muller's method, Chebyshev's method, multi-point method, Modified secant and Newton Raphson method, Methods of Multiple roots, Convergence of Methods.

Unit 4-

Solution of Linear Systems: Elimination with and without pivoting, Triangular factorization, Error and residual of an approximate solution, Backward error and iterative improvement. Polynomial interpolation: Existence and uniqueness of interpolation polynomial, error of interpolating polynomial, Interpolation using differences.

Unit 5-

Extrapolation methods, Numerical Differentiation, Numerical Integration: Newton Cote's integration, Solution of ODE's.

Books Recommended:

[1] John P. Hayes, Computer Architecture and Organization,3rd ed, McGraw Hill, 1998.
[2] Nicholas Carter, Computer Architecture, 2nd ed., Schaum's Outline Series, 2011.
[3] S.S. Sastry, Introductory Methods of Numerical Analysis, 3rd ed., Prentice Hall of India,1998.
[4] M.K. Jain, S.R.K.Iyengar and R.K.Jain, Numerical Methods for Scientific and Engineering Computations, Wiley Eastern Ltd., 1984.
[5] G. Shanker Rao, Numerical Analysis, 3rd ed., New Age International (P) Ltd.

Course Learning Outcomes: After studying this course the student will be able to:
CO1: Able to handle binary number system, computer arithmetic number base conversion.
CO2: Understand the errors, source of error and its effect on any numerical computations and also analyse the efficiency of any numerical algorithms.
CO3: Understand how to obtain numerical solution of nonlinear equations using bisection, secant, Newton and fixed-point iterations methods and convergence analysis of these methods.
CO4: Able to solve linear and nonlinear systems of equations numerically.
CO5: Understand Extrapolation methods, Numerical Differentiation, Numerical Integration: Newton Cote's integration, Solution of ODE's.

COURSE STRUCTURE
Under CBCS

M.Sc. MATHEMATICS

SEMESTER-II

Core Courses								
S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
1.	MAT-C201	Advanced Abstract Algebra-II	4	60	40	100	21	14
2.	MAT-C202	Lebesgue Measure and Integration	4	60	40	100	21	14
3.	MAT-C203	Topology-II	4	60	40	100	21	14
4.	MAT-C204	Differential Geometry	4	60	40	100	21	14
		Total Core Credits	**16**	**240**	**160**	**400**	**-**	**-**
Generic Elective (Any one of the following)								
5.	MAT-GE205	Number Theory	4	60	40	100	21	14
6.	MAT-GE206	Wavelet Analysis	4	60	40	100	21	14
7.	MAT-GE207	Quantitative Techniques	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
8.	MAT-C208	Comprehensive Viva-Voce	4	-	-	100	35	-
	Total (Core+ Generic Elective + Comprehensive Viva)		**24**	**300**	**200**	**600**	**-**	**-**

M.Sc. MATHEMATICS (Under CBCS)

SEMESTER-II

Course Code: MAT-C201 Advanced Abstract Algebra-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: In this course a new algebraic structure, namely, modules is introduced and studied in detail. Modules are the generalization of vector spaces when the underlying field is replaced by an arbitrary ring. The study of modules over a ring also provides an insight into the structure of ring.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Introduction to Modules, Examples, Submodules, Quotient modules, Homomorphism and Isomorphism, Finitely generated modules, Cyclic modules.

Unit 2- Simple modules, Semi-simple modules, free modules, Schur's lemma.

Unit 3- Noetherian and Artinian modules and rings, Hilbert bases theorem, Wedderburn-Artin theorem.

Unit 4- Uniform modules, Primary modules and Noether-Lasker theorem, Fundamental structure theorem of modules over a Principal Ideal Domain and its application to finitely generated abelian groups.

Unit 5- Similarity of linear transformations, Invariant subspaces, Reduction to triangular forms, Nilpotent transformations, Index of nilpotency, Invariants of a nilpotent transformation, The Primary decomposition theorem.

Recommended Books:

[1] I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd. New Delhi, 1975.
[2] Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
[3] P.B. Bhattacharya, S.K.Jain and S.R.Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.

Reference Books:

[1] N. Jacobson, Basic Algebra, Vols. I & II, W.H. Freeman, 1980(also published by Hindustan Publishing Company).
[2] S. Kumaresan, Linear Algebra-A Geometric Approach, Prentice Hall of India Ltd.
[3] I.S. Luther and I.B.S. Passi, Algebra, Vol.I-Groups, Vol. II-Rings, Narosa Publishing House (V0l. I-1996, Vol. II- 1999).

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Modules, Identify and construct example of module sand apply homomorphism theorems on thesame.

CO2: Distinguish between free, simple and semi-simple modules.

CO3: Understand Noetherian and Artinian modules and rings, Able to prove Hilbert bases theorem, Wedderburn-Artin theorem.

CO4: Understand Uniform modules, Primary modules and able to prove Noether-Lasker theorem.

CO5: Able to Understand similarity of linear transformations, triangular forms, Nilpotent transformations, Able to prove the Primary decomposition theorem.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-C202 Lebesgue Measure and Integration

Course Objectives: This course provides the essential foundations of important aspect of mathematical analysis. Measure theory and theory of the integration have numerous applications in other branches of pure and applied mathematics, for example in the theory of (partial) differential equations, functional analysis and fractal geometry. The objective of this course is to give mathematical foundation to probability theory and statistics, and on the real line it gives a natural extension of the Riemann integral which allows for better understanding of the fundamental relations between differentiation and integration.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-Lebesgue outer measure, Measurable sets, Regularity, Measurable function, Borel and Lebesgue measurability, Non-measurable sets.
Unit 2- Integration of non-negative functions, The general integral, Integration of series, Riemann and Lebesgue integrals.
Unit 3- The four derivatives, Functions of bounded variations, Lebesgue differentiation theorem, Differentiation and integration.
Unit 4- The L^p -spaces, Convex functions, Jensen's inequality, Hölder and Minkowski inequalities, Completeness of L^p .
Unit 5- Dual of space, Convergence in measure, Uniform convergence and Almost uniform convergence.

Recommended Books:
[1] G.de Barra, Measure Theory and Integration, Wiley-Eastern Ltd.,1981.

Reference Books:
[1] Walter Rudin, Principles of Mathematical Analysis (3rd Edition), McGraw-Hill, Kogakusha, 1976, International Student Edition.
[2] H.L. Royden, Real Analysis, Macmillan Publishing Co. Inc., 4th Edition, New York, 1993.
[3] I.K.Rana, An Introduction to Measure and Integration, Narosa Publishing House, 1997.
[4] P.K.Jain and V.P.Gupta, Lebesgue Measure and Integration, New-Age International (P) Ltd., New Delhi, 1986.

Course Learning Outcomes: After studying this course the student will be able to:
CO1: Understand and identify Lebesgue outer measure, Measurable sets, Regularity, Measurable function, Borel and Lebesgue measurability, Non-measurable sets.
CO2: Able to do Integration of non-negative functions, The general integral, Integration of series, Able to apply Riemann and Lebesgue integrals.
CO3: Understand the four derivatives, Functions of bounded variations, Lebesgue differentiation theorem.
CO4: Understand the L^p -spaces, Convex functions, Jensen's inequality, Able to prove Hölder and Minkowski inequalities, To check Completeness of L^p .
CO5: Understand Dual of space, Convergence in measure, Uniform convergence and Almost uniform convergence.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-II
Course Code: MAT-C203 Topology-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: It is a second course in Topology with main objective to teach students many important results on several useful topics including local compactness, one point compactification, separation axioms, Urysohn lemma, Tietze extension theorem, Tychonoff's theorem, Filters and Nets. In addition, the course aims to provide students the awareness of tools for carrying out advanced research later in Topology and related areas.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-Separation Axioms- T_0, T_1, T_2, T_3, T_4 -spaces, Their characterization and basic properties, Urysohn's lemma, Tietze extension theorem.

Unit 2- Compactness, Continuous functions and Compact sets, Basic properties of compactness, Compactness and finite intersection property, Sequentially and countably compact sets, Local compactness and one point compactification, Stone-Cech compactification, Compactness in metric spaces, Equivalence of compactness, Countable compactness and Sequential compactness in metric spaces.

Unit 3- Tychonoff product topology in terms of standard subbase and its characterizations, Projection maps, Separation axioms and product spaces, Connectedness and product spaces, Compactness and product spaces, Tychonoff's theorem, Countability and product spaces.

Unit 4- Filters, Filter base, Convergence of filters, Cluster points of a filter, Ultrafilters, Ultrafilters and compactness.

Unit 5- Nets- Topology and convergence of nets, Hausdorffness and nets, Ultranets, Compactness and nets, Canonical way of converting nets to filters and vice-versa. Embedding and Metrization, Embedding lemma and Tychonoff embedding, Urysohn Metrization theorem.

Recommended Books:

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

Reference Books:

[1] K.D.Joshi, Introduction to General Topology, Willey Eastern Limited, 1983.
[2] G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.
[3] J.Dugundji, Topology, Allyn and Bacon, 1966(Reprinted in India by Prentice-Hall of India Pvt. Ltd.).
[4] N. Bourbaki, General Topology Part-I (Transl.) Addition Wesley Reading 1966.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand separation axioms T_0, T_1, T_2, T_3, T_4 -spaces their characterization and basic properties.

CO2: Understand compactness, sequentially and countably compact sets, Stone-Cech compactification.

CO3: Understand Tychonoff product topology in terms of standard subbase and its characterizations, Able to prove Tychonoff's theorem, Understand Countability and product spaces.

CO4: Understand Filters and Ultrafilters.

CO5: Understand Nets, Embedding and Metrization, Able to prove Urysohn Metrization theorem.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-C204 Differential Geometry

Course Objectives: The objective of this course is to study geometry of curves and surfaces in three dimensional space using calculus techniques.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Three-dimensional Euclidean space, Parametric representation of a curve and a surface, Linear element of a curve, Tangent to a curve, Osculating plane, Contact of surface with a curve.

Unit 2-

Curvature and principal normal, Circle of curvature, Centre and radius of curvature, Binomial and torsion, Plane curve, Frenet-Serret formulae, Helices.

Unit 3-

Locus of centre of curvature, Osculating sphere, Locus of centre of spherical curvature, Involutes and Evolutes of a curve, Co-ordinates in terms of arc-length parameter, Intrinsic equation of a curve.

Unit 4-

Various forms of Surfaces, Explicit form, Gaussian and Monge's forms, Different types of Surfaces, right helicoids, Conicoid, Surface of Revolution, Tangent plane to a surface, One Parameter family of a surfaces, their characteristic curves and envelope. Ruled surfaces: Developables and skew-surfaces, Properties of Developable, Developable associated with space-curves.

Unit 5-

Curvilinear co-ordinates, Fundamental Magnitude of first order Christoffel symbols, Direction on a surfaces, Angle between two directions. Orthogonality and parallelism of two directions determined by a quadratic equation. Inclinations of directions with parametric curves. Normal to a surface, Fundamental magnitudes of second order. Derivatives of unit normal to a surface.

Recommended Books:

[1] R.S. Mishra, A course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad,1965.
[2] B.B.Sinha, Differential Geometry-An Introduction, Shyam Prakashan Mandir, Allahabad, 1978.

Reference Books:

[1] C.E.Weatherburn, An Introduction to Tensor Calculus and Riemannian Geometry, Cambridge University Press, London, 1942 and Radha Publishing House Calcutta, Indian Edition, 1995.
[2] T.J.Willmore, Differential Geometry, Oxford University Press, London, 1959 and Indian XI Edition, New Delhi, 1993.
[3] L.P. Eisenhart, Differential Geometry with the use of Tensors, Princeton University Press, New Jersey, 1949.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand parametric representation of a curve and a surface, Osculating Plane.

CO2: Understand curvature and principal normal, Circle of curvature, Centre and radius of curvature, Binomial and torsion, Plane curve, Able to prove Frenet-Serret formulae.

CO3: Understand Locus of centre of curvature, Osculating sphere, Locus of centre of spherical curvature, Involutes and Evolutes of a curve.

CO4: Understand various forms of Surfaces such as Explicit form, Gaussian and Monge's forms, Able to derive tangent plane to a surface, Understand Ruled surfaces, Developable and skew-surfaces.

CO5: Introduce with curvilinear co-ordinates, Understand Fundamental Magnitude of first order, Christoffel symbols, Normal to a surface, Fundamental magnitudes of second order.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-II

Generic Elective (Any one of the following)								
S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
5.	MAT-GE205	Number Theory	4	60	40	100	21	14
6.	MAT-GE206	Wavelet Analysis	4	60	40	100	21	14
7.	MAT-GE207	Quantitative Techniques	4	60	40	100	21	14
Total Generic Elective Credit			**4**	**60**	**40**	**100**	**-**	**-**
8.	MAT-C208	Comprehensive Viva-Voce	4	-	-	100	35	-
	Total (Core+ Generic Elective + Comprehensive Viva)		**24**	**300**	**200**	**600**	**-**	**-**

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-II
Course Code: MAT-GE205 Number Theory

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The purpose of the course is to give a simple account of classical number theory, prepare students to graduate-level courses in number theory and algebra, and to demonstrate applications of number theory (such as public-key cryptography). Upon completion of the course, students will have a working knowledge of the fundamental definitions and theorems of elementary number theory, be able to work with congruences, solve congruence equations and systems of equations with one and more variables, and be literate in the language and notation of number theory. They will also have an exposure to cryptography.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Divisibility: Some basic terms and properties, Division algorithm, Common divisor, Greatest Common Divisor (gcd), Theorems on gcd, Euclid's lemma, Relatively prime, Euclidean algorithm, least common multiple (lcm), Theorems on lcm, Fundamental theorem of arithmetic, Euclid's theorem.

Unit 2-

Congruences: Theorem of Congruences, Residue and Complete residue system, Reduced residue system, Euler's ϕ-function, Euler's theorem.

Unit 3-

Fermat's theorem, Wilson's theorem, Converse of Wilson theorem, Solutions of Congruences, Degree of Congruences, Chinese remainder theorem, Method of Solution of Congruences.

Unit 4-

Prime modules and Cryptography: Prime modules, Power residues, Number theory from algebraic point of view, Introduction of Cryptography, Some simple cryptosystems, Enciphering Matrices.

Unit 5-

Quadratic reciprocity: Quadratic residues, Gauss lemma, Gaussian reciprocity law, Jacobi symbol, Greatest integer function, Arithmetic function, multiplication of arithmetic functions, Möebius function, Möebius inversion formula, Converse of Möebius formula, Recurrence functions, Fibonacci numbers.

Recommended Books:

[1] Niven and Zuckermann, An Introduction to Theory of Numbers, Wiley Eastern Ltd.
[2] Ireland and Rosen,A Classical Introduction to Modern Number Theory, Springer Verlag.
[3] Tom Apostol, Introduction to Analytic Number Theory, Narosa Publications, New Delhi.
[4] H. Delfs and H. Knebl, Introduction to Cryptography, Springer.
[5] N. Koblitz, Algebraic Aspects of Cryptography, Springer.

Course Learning Outcomes: Upon completion of this course, the student will be able to:

CO1: Understand the properties of divisibility and prime numbers, compute the greatest common divisor and least common multiples and handle linear Diophantine equations.

CO2: Understand the operations with congruences, linear and non-linear congruence equations.

CO3: Understand and apply Chinese Remainder Theorem, Lagrange theorem, Fermat's theorem, Wilson's theorem.

CO4: Understand prime modules and Cryptography.

CO5: Apply arithmetic functions in areas of mathematics.

M.Sc. MATHEMATICS
SEMESTER-II
Course Code: MAT-GE206 Wavelet Analysis

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The main objectives of this course is to study Fourier and inverse Fourier transforms convolution and delta function, Fourier transform of square integrable functions, wavelet transform, time frequency Analysis, Gabor transform, Dyadic wavelets and inversion, frames, Wavelet series, Scaling functions and wavelets, Multi resolution analysis, compactly supported wavelets and their duals, orthogonal wavelets and wavelet packet, orthogonal decomposition of wavelet series.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 6 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Fourier analysis: Fourier and inverse Fourier transforms, Convolution and delta function, Fourier transform of Square integrable functions. Fourier series, Poisson's Summation formula.

Unit 2-

Wavelet Transforms and Time Frequency Analysis: The Gabor Transform. Short-time Fourier transforms and the uncertainty principle. The integral wavelet transforms Dyadic wavelets and inversions.

Unit 3-

Frames, Wavelet Series. Scaling Functions and Wavelets, Multi resolution analysis, scaling functions with finite two scale relations. Direct sum decomposition of $L^2(R)$: Linear phase filtering.

Unit 4-

Compactly supported wavelets, Wavelets and their duals, Orthogonal Wavelets and Wavelet packets, Example of orthogonal Wavelets.

Unit 5-

Identification of orthogonal two-scale symbols, Construction of Compactly supported orthogonal wavelets, Orthogonal wavelet packets, orthogonal decomposition of wavelet series.

Recommended Books:

[1] C. K. Chui, A First Course in Wavelets, Academic press NY 1996.
[2] I. Daubechies, Ten Lectures on Wavelets, Society for Industrial and Applied Maths, 1992.

Course Learning Outcomes: After the course the students will be able to:

CO1: Apply arithmetic functions in areas of mathematics.

CO2: Understand Wavelet Transforms and Time Frequency Analysis.

CO3: Able to Understand and Analyze Frames, Wavelet Series. Scaling Functions and Wavelets.

CO4: Understand Compactly supported wavelets, Wavelets and their duals, Orthogonal Wavelets and Wavelet packets, Example of orthogonal Wavelets.

CO5: Able to construct Compactly supported orthogonal wavelets, Orthogonal wavelet packets, orthogonal decomposition of wavelet series.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-II
Course Code: MAT-GE207 Quantitative Techniques

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The main objectives of this course is to study basic ideas of measures of central tendency, Measures of Dispersion, Standard Deviation, Relation between Standard Deviation and other Measures, , Measure of Skewness, Methods of Least Square, Curve Fitting, Basic Concepts of Sampling, Efficiency of Sampling Methods.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Introduction to Statistics, Statistics and Statistical Methods, Characteristics of Statistics, Functions of Statistics, Limitations of Statistics, Statistics in Business and Management, Distrust of Statistics.

Unit 2- Data Collection, Data Classification, Measures of Central Tendency, Measures of Dispersion, Objectives of Measuring Dispersion, Characteristics of Measure of Dispersion, Range, Quartile Deviation, Average Deviation, Standard Deviation, Relation between Standard Deviation and other Measures, Relative Measures of Dispersion, Lorenz Curve.

Unit 3- Skewness, Measure of Skewness, Moments, Moments about the Mean in term of Moments about any point, Effect of change of Origin and Scale on Moments, Factorial Moments, Absolute Moments, Sheppard's Corrections for Moments, Charliers's Checks, Pearson's β and γ Coefficients, Kurtosis.

Unit 4- Methods of Least Square, Curve Fitting, Normal Equations, Fitting of the curve of the type $y = ab^x$, $y = ax^b$, $y = ae^{bx}$. Correlation Analysis, Regression Analysis.

Unit 5- Introduction to Sampling Techniques, Need for Sampling, Basic Concepts, Efficiency of Sampling Methods, Alternative Sampling Methods.

Books Recommended:

[1] Ken Black, Business Statistics for Contemporary Decision making, 5th edition, Wiley Publications (Indian Edition).
[2] D.R. Anderson, D.J. Sweeney and T.A Williams, Statistics for Business and Economics, 12th edition, Cengage Learning.
[3] T. N. Shrivastava and Shailja Rego, Statistics for Management, 2nd edition, TMH.
[4] S. P. Gupta, Statistical Methods, 34th edition, Sultan Chand & Sons.
[5] M. Ray, H.R. Sharma and Chaudhary, Mathematical Statistics, 11th edition, Ram Prasad and Sons, 2006.

Course Learning Outcomes: After studying this course the student will be able to

CO1: Understand need of Statistics, Characteristics and Limitations of Statistics.

CO2: Able to Data Collection, Data Classification and Data Gathering, Drafting Questionnaires, Sample Selection, Data Presentation.

CO3: Understand and apply Measure of Skewness**.**

CO4: Understand and apply Methods of Least Square, Curve Fitting**.**

CO5: Understand and apply Sampling Techniques and Need for Sampling.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-III

S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
Core Courses								
1.	MAT-C301	Functional Analysis-I	4	60	40	100	21	14
2.	MAT-C302	Advanced Special Functions-I	4	60	40	100	21	14
3.	MAT-C303	Riemannian Geometry-I	4	60	40	100	21	14
		Total Core Credits	**12**	**180**	**120**	**300**	**-**	**-**
Discipline Centric Elective (Any one of the following)								
4.	MAT-DCE304	Integral Transforms-I	4	60	40	100	21	14
5.	MAT-DCE305	Differential Geometry of Manifolds-I	4	60	40	100	21	14
6.	MAT-DCE306	General Theory of Relativity and Cosmology –I	4	60	40	100	21	14
		Total Discipline Centric Elective Credits	**4**	**60**	**40**	**100**	**-**	**-**
Generic Elective (Any one of the following)								
7.	MAT-GE307	Operations Research-I	4	60	40	100	21	14
8.	MAT-GE308	Advanced Discrete Mathematics-I	4	60	40	100	21	14
9.	MAT-GE309	Bio-Mathematics	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C310	Comprehensive Viva-Voce	4	-	-	100	35	-
		Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)	**12+4+4+4= 24**	**300**	**200**	**500 +100 =600**	**-**	**-**

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-III
Course Code: MAT-C301 Functional Analysis-I

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: 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.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Normed linear spaces, Banach spaces and Examples, Properties of normed linear spaces.

Unit 2- Subspaces, Quotient space of normed linear space and its completeness, Completion of normed linear spaces.

Unit 3- Bounded linear operators and continuous operators on normed linear spaces, Spaces of bounded linear operators.

Unit 4- Finite dimensional normed linear spaces, Basic properties of finite dimensional normed linear spaces, Equivalent norms, Riesz Lemma and Compactness.

Unit 5-Bounded linear functionals, Dual spaces with examples.

Recommended Books:

[1] P.K. Jain, O.P. Ahuja and Khalil Ahmad, Functional Analysis, New Age International (P) Limited, 1997.

[2] K.K. Jha, Functional Analysis and its Applications, Students' Friend, 1986.

[3] B.V. Limaye, Functional Analysis, Wiley Eastern Ltd.

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

[5] S.K. Bose, Functional Analysis,

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Normed linear spaces, Banach spaces, Properties of normed linear spaces.

CO2: Understand Subspaces, Quotient space of normed linear space and its completeness, Completion of normed linear spaces.

CO3: Able to check boundedness of a linear operator and relate to continuity.

CO4: Able to prove Riesz-lemma and compactness.

CO5: Understand Bounded linear functionals, Dual spaces with examples.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-III

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-C302 Advanced Special Functions-I

Course Objectives: The objectives of this course is to study The Euler or Mascheroni constant γ, A series for Γ'(z)/ Γ(Z), Beta function, Factorial function, Legendre's duplication formula, Gauss multiplication theorem, Hypergeometric and Generalized hypergeometric functions, Hyperhgeometrical differential equation and its solutions, F(a,b;c;z) as function of its parameters, Generating function, Bessel Function and Legendre polynomials.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Gamma and Beta Functions: The Euler or Mascheroni constant γ, Gamma function, A series for Γ'(z)/ Γ(Z), Difference equation Γ(z+1) = z Γ(z).

Unit 2- Beta function, value of Γ(z) Γ(1-z), Factorial function, Legendre's duplication formula, Gauss multiplication theorem.

Unit 3- Hypergeometric and Generalized hypergeometric functions: Function ${}_2F_1$(a,b;c;z) A simple integral form, Evaluation of ${}_2F_1$(a,b;c;z), Contiguous function relations.

Unit 4- Hypergeometrical differential equation and its solutions, F(a,b;c;z) as function of its parameters. Elementary series manipulations, Simple transformation, Relations between functions of z and 1-z.

Unit 5- Bessel Function and Legendre polynomials: Definition of J_n(Z), Bessel's differential equation, Generating function, Bessel's integral with index half and an odd integer.

Recommended Books:

[1] E.D. Rainville, Special Functions, The Macmillan Co., New York, 1971.
[2] H.M.Srivastava, K.C.Gupta and S.P.Goyal, The H-function of One and Two variables with applications, South Asian Publication, New Delhi.
[3] N. Saran, S.D.Sharma and T.N. Trivedi, Special Functions with applications, Pragati Prakashan, 1986.
[4] N.N. Lebdev, Special functions and their applications, Prentice Hall, Englewood Cliffs, New Jersey, USA, 1965.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Gamma and Beta Functions, Difference equation Γ(z+1) = z Γ(z).

CO2: Able to derive value of Γ(z) Γ(1-z), Factorial function, Legendre's duplication formula, Gauss multiplication theorem..

CO3: Understand Hypergeometric and Generalized hypergeometric functions, Contiguous function relations.

CO4: Able to handle Hypergeometrical differential equation and its solutions, Elementary series manipulations.

CO5: Understand Bessel Function and Legendre polynomials, Generating function.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-III

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-C303 Riemannian Geometry-I

Course Objectives: The main objectives of this course is to study differentiable manifolds, tangent spaces, vector fields, Affine connections, Covariant derivatives, Curvature tensor, Exterior derivative, Riemannian manifolds, Riemannian connection, Schur's theorem,Geodesics in Riemannian manifolds, Projective curvature tensor, Conformal curvature tensor.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Definition and examples of Differentiable manifolds, Tangent spaces, Jacobian mappings.

Unit 2- Vector fields, Lie-bracket, Affine connections, Covariant derivatives, Curvature tensor, Bianchi identities.

Unit 3- Exterior algebra and Exterior derivative.

Unit 4- Riemannian manifolds, Riemannian connection, Curvature tensors, Sectional curvature, Schur's theorem.

Unit 5- Geodesics in Riemannian manifolds, Projective curvature tensor, Conformal curvature tensor.

Recommended Books:

[1] R.S. Mishra, A course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad,1965.

[2] B.B.Sinha, Differential Geometry-An Introduction, Shyam Prakashan Mandir, Allahabad, 1978.

Reference Books:

[1] C.E.Weatherburn, An Introduction to Tensor Calculus and Riemannian Geometry, Cambridge University Press, London, 1942 and Radha Publishing House Calcutta, Indian Edition, 1995.

[2] K.Yano, The Theory of Lie Derivatives and its Applications, North Holland Publishing Co. Amsterdam, 1957.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Differentiable manifolds, Tangent spaces, Vector fields.

CO2: Understand Affine connections, Covariant derivatives, Curvature tensor.

CO3: Able to understand and apply Exterior derivative and Exterior algebra.

CO4: Understand Riemannian manifolds, Riemannian connection, Sectional curvature, Able to Schur's theorem.

CO5: Able to introduce and analyze Geodesics in Riemannian manifolds, Projective curvature tensor, Conformal curvature tensor.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-III

Discipline Centric Elective (Any one of the following)								
S. No.	**Course Code**	**Title of the Course**	**Credit**	**Maximum Marks**		**Total**	**Minimum Pass Marks**	
				Theory	**Cont. Evln.**		**Theory**	**Cont. Evln.**
4.	MAT-DCE304	Integral Transforms-I	4	60	40	100	21	14
5.	MAT-DCE305	Differential Geometry of Manifolds-I	4	60	40	100	21	14
6.	MAT-DCE306	General Theory of Relativity and Cosmology –I	4	60	40	100	21	14
Total Discipline Centric Elective Credits			**4**	**60**	**40**	**100**	**-**	**-**
Generic Elective (Any one of the following)								
7.	MAT-GE307	Operations Research-I	4	60	40	100	21	14
8.	MAT-GE308	Advanced Discrete Mathematics-I	4	60	40	100	21	14
9.	MAT-GE309	Bio-Mathematics	4	60	40	100	21	14
Total Generic Elective Credit			**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C310	Comprehensive Viva-Voce	4	-	-	100	35	-
	Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)		**12+4+ 4+4= 24**	**300**	**200**	**500 +100 =600**	**-**	**-**

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-III
Course Code: MAT-DCE304 Integral Transforms-I

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: This course is intended to prepare the student with mathematical tools and techniques that are required in advanced courses offered in the applied mathematics and engineering programs. The objective of this course is to enable students to apply transforms for solving one dimensional and two dimensional heat conduction equations.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Laplace Transform and its Applications.

Unit 2-

Laplace Equations and related problems.

Unit 3-

Laplace's Wave Equations and related problems.

Unit 4-

One dimensional Heat conduction equations and its Applications.

Unit 5-

Two dimensional Heat Conduction Equations and its Applications.

Recommended Books:

[1] J.K. Goyal and K.P. Gupta, Integral Transforms, Pragati Prakashan.

[2] L. Debnath and D. Batta, Integral Transforms and Their Applications, 2nd ed., Chapman & Hall/CRC, 2007.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Laplace Transform and its Applications

CO2: Derive Laplace Equations and solve related problems.

CO3: Understand Laplace's Wave Equations and related problems.

CO4: Understand One dimensional Heat conduction equations and its applications.

CO5: Understand Two-dimensional Heat Conduction Equations and its applications.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-III

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-DCE305 Differential Geometry of Manifolds-I

Course Objective: The paper of Differential Geometry of Manifolds is introduced to M.Sc. classes for the study of differentiable manifolds, Tangent spaces, One parameter group of transformations, Lie-derivatives, Immersions and Embeddings, Distributions, Exterior algebra, Exterior derivative, Topological groups, Lie groups and Lie algebras, One parameter subgroup and Exponential maps, General linear groups, Principle fibre bundle, Linear frame bundle.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Definition and examples of differentiable manifolds, Tangent spaces, Jacobian map, One parameter group of transformations.

Unit 2-

Lie-derivatives, Immersions and Embeddings, Distributions, Exterior algebra, Exterior derivative.

Unit 3-

Topological groups, Lie groups and Lie algebras, Product of two Lie groups.

Unit 4-

One parameter subgroup and Exponential maps, Examples of Lie groups.

Unit 5-

Homomorphism and Isomorphism, Lie transformation groups, General linear groups, Principle fibre bundle, Linear frame bundle.

Recommended Books:

[1] B.B.Sinha, An Introduction to Modern Differential Geometry, Kalyani Publishers, New Delhi, 1982.
[2] K.Yano and M.Kon, Structures on Manifolds, World Scientific Publishing Co.Pvt.Ltd., 1984.

Reference Books:

[1] R.S.Mishra, A Course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., 1965.
[2] R.S. Mishra, Structures on Differentiable Manifolds and their Applications, Chandrama Prakashan Allahabad, 1984.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Able to demonstrate an intuitive and computational understanding of differentiable manifolds, Tangent spaces, Jacobian map, One parameter group of transformations.

CO2: Understand Lie-derivatives, Immersions and Embeddings, Distributions.

CO3: Able to Understand and Analyze Topological groups, Lie groups and Lie algebras, One parameter subgroup and Exponential maps.

CO4: Able to illustrate Lie groups, Understand One parameter subgroup and Exponential maps.

CO5: Able to understand and distinguish Principle fibre bundle, Linear frame bundle.

M.Sc. MATHEMATICS (Under CBCS) SEMESTER-III	Credit: 4	Max. Marks	Min. Pass Marks
	Theory	60	21
	Cont. Evln.	40	14

Course Code: MAT-DCE306 General Theory of Relativity and Cosmology-I

Course Objectives: The objective of this course is to study Transformation of coordinates, Einstein summation convention and Kroneker delta, Tensors, Algebra of tensors, Contraction of tensors and Quotient law, Riemannian metric, Fundamental tensor, Christoffel symbols, Covariant derivatives, Intrinsic derivatives, Geodesics, Riemann Christoffel curvature tensor and its symmetry properties, Bianchi identities, Ricci tensor, Einstein tensor, General theory of Relativity, Principle of equivalence and general covariance, Newtonian approximation of equation of motion, Search for Einstein's field equations, Its reduction to Poisson's equation, Gravitational field in empty space.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Transformation of coordinates, Einstein summation convention and Kroneker delta, Tensors, Algebra of tensors, Group properties of transformations, Symmetric and skew symmetric tensors.

Unit 2- Contraction of tensors and Quotient law, Riemannian metric, Fundamental tensor, Angle between two coordinate curves, Conjugate and associated tensors, Levi-Civita tensor.

Unit 3- Christoffel symbols, Transformation law of Christoffel symbols, Covariant derivatives, Intrinsic derivatives, Gradient, Divergent and Curl.

Unit 4- Geodesics, Riemann Christoffel curvature tensor and its symmetry properties, Bianchi identities, Ricci tensor, Einstein tensor.

Unit 5- General theory of Relativity, Principle of equivalence and general covariance, Geodesic principle, Newtonian approximation of equation of motion, Search for Einstein's field equations, Its reduction to Poisson's equation, Gravitational field in empty space.

Recommended Books:

[1] S.R.Roy and Raj Bali: Theory of relativity, Jaipur Publishing House, Jaipur, 1987.
[2] S.K. Shrivastava: General Theory and Cosmology, P.H.I., New Delhi.
[3] J.V.Narlikar: General Relativity and Cosmology, Macmillan Comp. of India Ltd.1978.

References:

[1]C.E.Weatherburn, An Introduction to Riemannian Geometry and the Tensor Calculus, Cambridge University Press, 1950.
[2] H. Stephani,General Relativity: An Introduction to the theory of the gravitational field, Cambridge University Press, 1982.
[3] A.S. Eddington, The Mathematical theory of Relativity, Cambridge University Press, 1965.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand tensors, Algebra of tensors, Symmetric and skew symmetric tensors.

CO2: Able to Contraction of tensors and understand Quotient law, Riemannian metric, Levi-Civita tensor.

CO3: Able to Understand Christoffel symbols, Transformation law of Christoffel symbols, Covariant derivatives, Gradient, Divergent and Curl.

CO4: Understand Geodesics, Riemann Christoffel curvature tensor and its symmetry properties, Ricci tensor, Einstein tensor.

CO5: Understand and work with General theory of Relativity, Principle of equivalence and general covariance, Search for Einstein's field equations, Gravitational field in empty space.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-III

Generic Elective (Any one of the following)								
S. No.	**Course Code**	**Title of the Course**	**Credit**	**Maximum Marks**		**Total**	**Minimum Pass Marks**	
				Theory	**Cont. Evln.**		**Theory**	**Cont. Evln.**
7.	MAT-GE307	Operations Research-I	4	60	40	100	21	14
8.	MAT-GE308	Advanced Discrete Mathematics-I	4	60	40	100	21	14
9.	MAT-GE309	Bio-Mathematics	4	60	40	100	21	14
Total Generic Elective Credit			**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C310	Comprehensive Viva-Voce	4	-	-	100	35	-
	Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)		**12+4+ 4+4= 24**	**300**	**200**	**500 +100 =600**	**-**	**-**

M.Sc. MATHEMATICS (Under CBCS)

SEMESTER-III

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-GE307 Operations Research-I

Course Objectives: Operations research helps in solving problems in different environments that needs decisions. This module aims to introduce students to use quantitative methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Operations Research and its scope, Origin and Development of Operations Research, Characteristics of Operations Research.

Unit 2-

Model in Operations Research, Phase of Operations Research, Use and Limitations of Operations Research, Linear Programming Problems.

Unit 3-

Mathematical Formulation, Graphical Solution Method.

Unit 4-

General Linear Programming Problem: Simplex Method exceptional cases, artificial variable techniques, Big M method, two phase Method and cyclic Problems, Problem of degeneracy.

Unit 5-

Duality, Fundamental properties of duality and theorem of duality.

Recommended Books:

[1] Kanti Swarup, P.K.Gupta and Manmohan, Operations Research, Sultan Chand & Sons, New Delhi.

Reference Books:

[1] S. D. Sharma, Operations Research, Kedar Nath Ram Nath & Co., 1996.
[2] F.S. Hiller and G.J.Lieberman, Industrial Engineering Series,1995.
[3] G. Hadley, Linear Programming, Narosa Publishing House,1995.
[4] G. Hadley, Linear and Dynamic Programming, Addison-Wesley Reading Mass.
[5] H.A. Taha, Operations Research-An Introduction, Macmillan Publishing Co.Inc. New York.
[6] Prem Kumar Gupta and D.S.Hira, Operations Research-An Introduction, S.Chand & Sons Company Ltd.,New Delhi.
[7] N.S.Kambo, Mathematical Programming Technique, Affilated East West Pvt.Ltd.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand scope, origin and development of Operations Research, characteristics of Operations Research.

CO2: Understand Model in Operations Research, Use and limitations of Operations Research, Able to introduce Linear Programming Problems.

CO3: Able to formulate some real-life problems into Linear programming problem.

CO4: Able to apply the simplex method to find an optimal vector for the standard linear programming.

CO5: Able to prove the optimality condition for feasible vectors for Linear programming problem and Dual Linear programming problem.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-III

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-GE308 Advanced Discrete Mathematics-I

Course Objectives: The objective of this course is to prepare students to develop mathematical foundations to understand and create mathematical arguments required in learning many mathematics and computer science courses and to motivate students how to solve practical problems using discrete mathematics.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Subgroups and Monoids-Definitions and examples of Semigroups and Monoids (including those pertaining to concatenation operation). Homomorphism of semigroups and Monoids. Congruence relation and quotient semigroups. Subsemigroup and submonoids. Direct products, Basic homomorphism theorem.

Unit 2- Lattices- Lattices as partially ordered sets, Their properties, Lattices as algebraic systems, Sublattices, Direct products and homomorphisms, Some special lattices e.g. Complete, Complemented and Distributive lattices.

Unit 3- Boolean Algebras- Boolean Algebras as lattices, Various Boolean identities, The switching algebra example, Subalgebras, Direct products and homomorphisms, Join irreducible elements, Atoms and Minterms, Boolean forms and their equivalence, Minterm Boolean forms, Sum of products, canonical forms, Minimization of Boolean functions, Application of Boolean algebra to switching theory (using AND, OR & NOT gates), The Karnaugh map method.

Unit 4- Graph theory- Definition of (undirected) graphs, Paths, Circuits, Cycles and subgraphs, Induced subgraphs, Degree of vertex, Connectivity, Planar graphs and their properties, Trees.

Unit 5- Euler's formula for connected planar graphs, Complete and Complete Bipartite graphs, Kurtowski's theorem (statement only) and its use. Spanning trees, Cut-Sets, Fundamental Cut-Sets and Cycles, Minimal spanning trees and Kruskal's algorithm, Matrix representation of graphs.

Recommended Books :

[1] J.P.Trambly and R. Manohar, Discrete Mathematical Structures with Application to Computer Science, McGraw-Hill book Co., 1997.

[2] N. Deo, Graph Theory with Application to Engineering and Computer Sci., Prentice Hall of India.

Reference Books:

[1] J.L. Gersting, Mathematical Structure for Computer Science (3rd Edition), Computer Science Press, New York.

[2] Seymour Lepschutz, Finite Mathematics (Internat. Edition, 1983), McGraw Hill Co., New York.

[3] S.Wiitala, Discrete Mathematics-A Unified Approach, McGraw Hill Book Co.

[4] J.E. Hopcroft and J.D. Ullman, Introduction to Automata Theory Languages and Computation, Narosa Publishing House.

[5] C.L. Liu, Elements of Discrete Mathematics, McGraw Hill Book Co.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Able to understand and analyze Subgroups, Semigroups, Monoids, Homomorphism, Congruence relation.

CO2: Able to Understand Lattices, Complete, Complemented and Distributive lattices.

CO3: Understand Boolean Algebras, canonical forms, Application of Boolean algebra to switching theory.

CO4: Understand and distinguish various Graphs, Paths, Circuits, Cycles and subgraphs, Induced subgraphs, Planar graphs, Trees.

CO5: Understand and prove Euler's formula for connected planar graphs, Kurtowski's theorem, Minimal spanning trees and Kruskal's algorithm.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-III

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Code: MAT-GE309 Bio-Mathematics

Course Objectives: The objective of this course is to show how mathematics and computing can be used in an integrated way to analyse biological systems and to introduce students to the application of mathematical modelling in the analysis of biological systems.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-Introduction, Definition and Scope of Bio-Mathematics, Role of Mathematics in BioSciences, Bio-fluid dynamics, Human Cardiovascular System and blood flow, Blood flow through artery with mild stenosis.

Unit 2-Two layered flow in a tube with mild stenosis, Pulsatile flow of blood, Analysis and Applications of arterial flow dynamics, derivation of aortic Diastolic-Systolic pressure waveforms, Moens-Korteweg expression for pulse wave velocity in an inviscid fluid filled elastic cylindrical arterial tube model.

Unit 3-Analysis and applications of left ventricular mechanics, analysis and applications of heart wave vibration, Human respiratory system.

Unit 4-Gas exchange and air flow in human lungs, Consumption and transport of Oxygen, Weibel's model for flows in human lung airways.

Unit 5-Diffusion, Fick's laws of diffusion, diffusion equation and its solutions, Modification of the diffusion equation, Diffusion in artificial kidney, Hemodialyser, Types of Hemodialyser.

Books Recommended:

[1] J.N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd., New Delhi, 1985.
[2] Y.C. Fung, Bio-Mechanics, Springer-Verlag, New York Inc., 1990.
[3] Stanley E. Charm and George S. Kurland, Blood flow and Microcirculation, John Wiley & Sons, 1974.
[4] S.A. Levin, Frontiers in Mathematical Biology, Springer-Verlag, 1994.
[5] S.K.Pundir & R. Pundir, Biomathematics, Pragati Prakashan, 2010.
[6] J. Mazumdar, An Introduction to Mathematical Physiology and Biology, Cambridge University Press.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Scope of Bio-Mathematics, Role of Mathematics in Bio-Sciences, Bio-fluid dynamics, Human Cardiovascular System and blood flow.

CO2: Able to understand Pulsatile flow of blood, Analysis and Applications of arterial flow dynamics.

CO3: Able to Analysis and applications of left ventricular mechanics, analysis and applications of heart wave vibration, Human respiratory system.

CO4: Understand Gas exchange and air flow in human lungs, Consumption and transport of Oxygen, Weibel's model for flows in human lung airways.

CO5: Understand Diffusion, Fick's laws of diffusion, diffusion equation and its solutions, Diffusion in artificial kidney.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-IV

S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
Core Courses								
1.	MAT-C401	Functional Analysis-II	4	60	40	100	21	14
2.	MAT-C402	Advanced Special Functions-II	4	60	40	100	21	14
3.	MAT-C403	Riemannian Geometry-II	4	60	40	100	21	14
		Total Core Credits	**12**	**180**	**120**	**300**	**-**	**-**
Discipline Centric Elective (Any one of the following)								
4.	MAT-DCE404	Integral Transforms-II	4	60	40	100	21	14
5.	MAT-DCE405	Differential Geometry of Manifolds-II	4	60	40	100	21	14
6.	MAT-DCE406	General Theory of Relativity and Cosmology –II	4	60	40	100	21	14
		Total Discipline Centric Elective Credits	**4**	**60**	**40**	**100**	**-**	**-**
Generic Elective (Any one of the following)								
7.	MAT-GE407	Operations Research-II	4	60	40	100	21	14
8.	MAT-GE408	Advanced Discrete Mathematics-II	4	60	40	100	21	14
9.	MAT-GE409	Cryptography	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C410	Comprehensive Viva-Voce	4	-	-	100	35	-
		Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)	**12+4+4+4= 24**	**300**	**200**	**500 +100 =600**	**-**	**-**
		Total Semester (I+II+III+IV)	**96**	**1200**	**800**	**2400**		

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-IV
Course Code: MAT-C401 Functional Analysis-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The main aim of this course is to provide students basic concepts of functional analysis to facilitate the study of advanced mathematical structures arising in the natural sciences and the engineering sciences and to grasp the newest technical and mathematical literature

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Uniform boundedness principle and some of its consequences, Open mapping and closed graph theorems.

Unit 2-

Hahn-Banach theorem for real linear spaces, Hahn-Banach theorem for complex linear spaces and normed linear spaces and some of its consequences, Reflexivity of Normed spaces.

Unit 3-

Inner product spaces, Examples and Properties, Convex sets, Riesz lemma on closed convex set, orthogonality of vectors, Projection theorem, Hilbert spaces.

Unit 4-

Orthonormal Sets, Bessel's inequality, Complete orthonormal sets and Parseval's Identity, Riesz representation theorem, Reflexivity of Hilbert spaces.

Unit 5-

Adjoint of an operator on a Hilbert space, Self-adjoint operators, Positive operators, Projection, Normal and Unitary operators.

Recommended Books:

[1] P.K.Jain, O.P. Ahuja and Khalil Ahmad, Functional Analysis, New Age International (P) Limited, 1997.

[2] K.K.Jha, Functional Analysis and its Applications, Students' Friend, 1986.

[3] B.V. Limaye, Functional Analysis, Wiley Eastern Ltd.

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

[5] S.K. Bose, Functional Analysis,

Course Learning Outcomes: Upon completion of this course, the student will be able to:

CO1: Understand uniform boundedness principle and some of its consequences, Open mapping and closed graph theorems.

CO2: Understand Hahn-Banach theorem and some of its consequences, Reflexivity of Normed spaces.

CO3: Understand inner product spaces, orthogonality and Hillbert spaces.

CO4: Able to prove Bessel's inequality and Parseval's Identity, Riesz representation theorem.

CO5: Able to apply linear operators in the formulation of differential and integral equations.

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-IV
Course Code: MAT-C402 Advanced Special Functions-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The objectives of this course is to study generating function for Legendre polynomials, Rodrigues formula, Bateman's generating function, Hermite polynomials, Laguerre Polynomials , Orthogonality, Jacobi Polynomials, Differential Recurrence Relations, Pure Recurrence Relations.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Generating function for Legendre polynomials, Rodrigues formula, Bateman's generating function, Additional generating functions, Hypergeometric forms of $P_n(X)$, Special properties of $P_n(X)$, Some more generating functions, Laplace's first integral form, Orthogonality.

Unit 2-

Definition of Hermite polynomials $H_n(X)$, Pure recurrence relations, Differential recurrence relations, Rodrigue's formula, Other generating functions, Orthogonality, Expansion of polynomials, more generating functions.

Unit 3-

The Laguerre Polynomials $L_n(X)$, Generating functions, Pure recurrence relations, Differential recurrence relation, Rodrigue's formula, Orthogonality, Expansion of polynomials, special properties, Other generating functions.

Unit 4-

Jacobi Polynomials, Bateman's Generating Functions, Rodrigues Formula, Orthogonality.

Unit 5-

Differential Recurrence Relations, Pure Recurrence Relations, Mixed Relations, Appell's functions of two variables, An elementary generating function.

Recommended Books:

[1] E.D. Rainville, Special Functions, The Macmillan Co., New York, 1971.

[2] H.M.Srivastava, K.C.Gupta and S.P.Goyal, The H-function of One and Two variables with applications, South Asian Publication, New Delhi.

[3] N. Saran, S.D.Sharma and T.N. Trivedi, Special Functions with applications, Pragati Prakashan, 1986.

[4] N.N.Lebdev, Special functions and their applications, Prentice Hall, Englewood Cliffs, New Jersey, USA, 1965.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Able to work with Generating function for Legendre polynomials, Understand Rodrigues formula, Bateman's generating function, Hypergeometric forms of $P_n(X)$, Orthogonality.

CO2: Understand Hermite polynomials, Pure recurrence relations, Differential recurrence relations.

CO3: Able to illustrate the Laguerre Polynomials $L_n(X)$, Jacobi Polynomials.

CO4: Understand Jacobi Polynomials, Bateman's Generating Functions.

CO5: Understand and distinguish Differential Recurrence Relations, Pure Recurrence Relations, Mixed Relations.

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

M.Sc. MATHEMATICS (Under CBCS)
SEMESTER-IV
Course Code: MAT-C403 Riemannian Geometry-II

Course Objectives: The main objectives of this course is to study Ricci's Coefficient of Rotation, Congruence, Gaussian and Riccian curvature, Submanifolds and hypersurfaces of a Riemannian manifold, Gauss Formulae, Weingarten formulae, Totally geodesic subspaces, Asymptotic direction, Meunier's theorem, Principal curvatures and Principal directions, Lines of curvature, Mainardi-Codazzi equations, Gauss Characteristic equation, Hyperplanes, Hyperspheres, Hyperquadratics, Joachimsthal's theorem, Lie-derivative of scalars, vectors and tensors, Killing equation, Lie derivative of Christoffel symbols.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Orthonormal Basis, Ricci's Coefficient of Rotation and the reason for their name, Congruence: geodesic, normal, irrotational and canonical, Gaussian and Riccian curvature.

Unit 2- Sub-manifolds and hypersurfaces of a Riemannian manifold, Tangent space, Tensor differentiation, Gauss Formulae, Normal curvatures and torsion, Weingarten formulae.

Unit 3- Totally geodesic subspaces, Asymptotic direction, Meunier's theorem, Principal curvatures and Principal directions, Lines of curvature, Mainardi-Codazzi equations, Gauss Characteristic equation.

Unit 4- Hyperplanes, Hyperspheres, Hyperquadratics, Sub-spaces and hypersurfaces, Joachimsthal's theorem.

Unit 5- Infinitesimal point transformation, Lie-derivative of scalars, vectors and tensors, Killing equation, Lie derivative of Christoffel symbols, Motion, Translation, Affine Motion and Conformal motion.

Recommended Books:

[1] R.S. Mishra, A course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad,1965.
[2] B.B.Sinha, Differential Geometry-An Introduction, Shyam Prakashan Mandir, Allahabad, 1978.

Reference Books:

[1] C.E.Weatherburn, An Introduction to Tensor Calculus and Riemannian Geometry, Cambridge University Press, London, 1942 and Radha Publishing House Calcutta, Indian Edition, 1995.
[2] K.Yano, The Theory of Lie Derivatives and its Applications, North Holland Publishing Co. Amsterdam, 1957.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Orthonormal Basis, Ricci's Coefficient of Rotation, Congruences.

CO2: Understand Submanifolds and hypersurfaces of a Riemannian manifold, Tangent space, Tensor differentiation.

CO3: Abletoprove Gauss Formulae, Weingarten formulae, Meunier's theorem, Mainardi-Codazzi equations, Gauss Characteristic equation, Joachimsthal's theorem, Killing equation.

CO4: Understand Hyperplanes, Hyperspheres, Hyperquadratics, Sub-spaces and hypersurfaces.

CO5: Understand Infinitesimal point transformation, Lie-derivative, Killing equation, Motion, Affine Motion and Conformal motion.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS
SEMESTER-IV

S. No.	Course Code	Title of the Course	Credit	Maximum Marks		Total	Minimum Pass Marks	
				Theory	Cont. Evln.		Theory	Cont. Evln.
Discipline Centric Elective (Any one of the following)								
4.	MAT-DCE404	Integral Transforms-II	4	60	40	100	21	14
5.	MAT-DCE405	Differential Geometry of Manifolds-II	4	60	40	100	21	14
6.	MAT-DCE406	General Theory of Relativity and Cosmology –II	4	60	40	100	21	14
		Total Discipline Centric Elective Credits	**4**	**60**	**40**	**100**	**-**	**-**
Generic Elective (Any one of the following)								
7.	MAT-GE407	Operations Research-II	4	60	40	100	21	14
8.	MAT-GE408	Advanced Discrete Mathematics-II	4	60	40	100	21	14
9.	MAT-GE409	Cryptography	4	60	40	100	21	14
		Total Generic Elective Credit	**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C410	Comprehensive Viva-Voce	4	-	-	100	35	-
		Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)	**12+4 +4+4 = 24**	**300**	**200**	**500 +100 =600**	**-**	**-**
		Total Semester (I+II+III+IV)	**96**	**1200**	**800**	**2400**		

M.Sc. MATHEMATICS (Under CBCS)

SEMESTER-IV

Course Code: MAT-C404 Integral Transforms-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The objective of this course is to enable students to apply Laplace transform to boundary value problems, electric circuits and to beams. It is also intended to study the complex Fourier transform, Fourier cosine and sine transform, properties of Fourier transforms, convolution and Parseval's identity, Fourier transform of the derivatives.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Application of Laplace Transform to Boundary Value Problems.

Unit 2-

Electric Circuits, Application to Beams.

Unit 3-

The Complex Fourier Transform, Inversion formula, Fourier cosine and sine transform.

Unit 4-

Properties of Fourier transforms, Convolution and Parseval's identity.

Unit 5-

Fourier transform of the derivatives, Finite Fourier sine and cosine transform, Inversion, Operational and combined properties Fourier transform.

Recommended Books:

[1] J.K. Goyal and K.P. Gupta, Integral Transforms, Pragati Prakashan.

[2] L. Debnath and D. Batta, Integral Transforms and Their Applications, 2nd ed., Chapman & Hall/CRC, 2007

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand application of Laplace transform to boundary value problems.

CO2: Understand Electric Circuits and their application to Beams.

CO3: Able to define the Complex Fourier Transform, Inversion formula, Fourier cosine and sine transform.

CO4: Understand Properties of Fourier transforms, Convolution and Parseval's identity.

CO5: Able to handle inversion, operational and combined properties of Fourier transform.

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

M.Sc. MATHEMATICS
SEMESTER-IV
Paper Code: MAT-DCE405 Differential Geometry of Manifolds-II

Course Objectives: The objective of this paper is to study Associated fibre bundle, Vector bundle, Induced bundle, Bundle homomorphisms, Riemannian manifolds, Riemannian connection, Curvature tensors, Geodesics in a Riemannian manifold, Submanifolds and Hypersurfaces, Almost complex manifolds, Contravariant and covariant almost analytic vector fields, F-connection.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 6 marks and section B of long answer type questions each carrying 10 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Associated fibre bundle, Vector bundle, Induced bundle, Bundle homomorphisms.

Unit 2-

Riemannian manifolds, Riemannian connection, Curvature tensors, Sectional curvature, Schur's theorem.

Unit 3-

Geodesics in a Riemannian manifold, Projective curvature tensor, Conformal curvature tensor.

Unit 4-

Submanifolds and Hypersurfaces, Normals, Gauss' formulae, Weingarten equations, Lines of curvature, Generalized Gauss and Mainardi-Codazzi equations.

Unit 5-

Almost complex manifolds, Nijenhuis tensor, Contravariant and covariant almost analytic vector fields, F-connection.

Recommended Books:

[1] B.B.Sinha, An Introduction to Modern Differential Geometry, Kalyani Pub., New Delhi, 1982.

[2] K.Yano and M.Kon, Structures on Manifolds, World Scientific Publishing Co.Pvt.Ltd., 1984.

Reference Books:

[1] R.S.Mishra, A Course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., 1965.

[2] R.S. Mishra, Structures on Differentiable Manifolds and their Applications, Chandrama Prakashan Allahabad, 1984.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand demonstrate Associated fibre bundle, Vector bundle, Induced bundle, Bundle homomorphisms.

CO2: Understand Riemannian manifolds, Riemannian connection, Curvature tensors, Sectional curvature and to prove Schur's theorem.

CO3: Understand Geodesics in a Riemannian manifold, Projective curvature tensor, Conformal curvature tensor.

CO4: Understand Submanifolds and Hypersurfaces, Gauss' formulae, Weingarten equations, Generalized Gauss and Mainardi-Codazzi equations.

CO5: Understand Almost complex manifolds, Nijenhuis tensor, Contravariant and covariant almost analytic vector fields, F-connection.

	Credit: 4	Max. Marks	Min. Pass Marks
M.Sc. MATHEMATICS			
SEMESTER-IV	Theory	60	21
Paper Code: MAT-DCE406 General Theory of Relativity and Cosmology-II	Cont. Evln.	40	14

Course Objectives: The objective of this course is to study Schwarzschild exterior solution and its isotropic form, Singularities in Schwarzschild line element, Advance of perihelion of a planet, Bending of light rays in a gravitational field, Radar echo delay, Energy-momentum tensor of a perfect fluid, Schwarzschild internal solution, Derivation of Einstein-field equation from variational principle, Static cosmological models, Einstein universe, de-Sitter universe, Difference between Einstein and de-Sitter universe, Non-static cosmological models, Derivation of Robertson-Walker metric.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 6 marks and section B of long answer type questions each carrying 10 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-Schwarzschild exterior solution and its isotropic form, Singularities in Schwarzschild line element, Canonical form of metric, Planetary orbits and analogues of Kepler's law in general relativity.

Unit 2- Advance of perihelion of a planet, Bending of light rays in a gravitational field, The gravitational red shift of spectral lines, Radar echo delay.

Unit 3- Energy-momentum tensor of a perfect fluid, Schwarzschild internal solution, Boundary conditions, Action Principle, Derivation of Einstein field equations from variational principle.

Unit 4- Cosmology: Static cosmological models, Einstein universe, Geometrical and Physical properties of Einstein universe.

Unit 5- de-Sitter universe, their derivation, Geometrical and Physical properties of de-Sitter universe, Difference between Einstein and de-Sitter universe. Non-static cosmological models, Derivation of Robertson-Walker metric.

Recommended Books:

[1] S.R.Roy and Raj Bali: Theory of relativity, Jaipur Publishing House, Jaipur, 1987.
[2] S.K. Shrivastava: General Theory and Cosmology, P.H.I., New Delhi.
[3] J.V.Narlikar: General Relativity and Cosmology, Macmillan Comp. of India Ltd.1978.

References:

[1]C.E.Weatherburn, An Introduction to Riemannian Geometry and the Tensor Calculus, Cambridge University Press, 1950.
[2] H. Stephani,General Relativity: An Introduction to the theory of the gravitational field, Cambridge University Press, 1982.
[3] A.S. Eddington, The Mathematical theory of Relativity, Cambridge University Press, 1965.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Able to derive Schwarzschild exterior solution and its isotropic form, Singularities in Schwarzschild line element.

CO2: Understand Bending of light rays in a gravitational field, Radar echo delay.

CO3: Illustrate Energy-momentum tensor of a perfect fluid, Schwarzschild internal solution, Boundary conditions.

CO4: Understand and work on Static cosmological models, Einstein universe.

CO5: Understand de-Sitter universe, Difference between Einstein and de-Sitter universe, Derivation of Robertson-Walker metric.

COURSE STRUCTURE

Under CBCS

M.Sc. MATHEMATICS

SEMESTER-IV

Generic Elective (Any one of the following)								
S. No.	**Course Code**	**Title of the Course**	**Credit**	**Maximum Marks**		**Total**	**Minimum Pass Marks**	
				Theory	**Cont. Evln.**		**Theory**	**Cont. Evln.**
7.	MAT-GE407	Operations Research-II	4	60	40	100	21	14
8.	MAT-GE408	Advanced Discrete Mathematics-II	4	60	40	100	21	14
9.	MAT-GE409	Cryptography	4	60	40	100	21	14
Total Generic Elective Credit			**4**	**60**	**40**	**100**	**-**	**-**
10.	MAT-C410	Comprehensive Viva-Voce	4	-	-	100	35	-
	Total (Core+ Discipline Centric Elective+ Generic Elective + Comprehensive Viva)		**12+4 +4+4 = 24**	**300**	**200**	**500 +100 =600**	**-**	**-**
	Total Semester (I+II+III+IV)		**96**	**1200**	**800**	**2400**		

M.Sc. MATHEMATICS (Under CBCS)

SEMESTER-IV

Course Code: MAT-GE407 Operations Research-II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The objective of this course is to introduce concepts of transportation and assignment problems and their solutions by various techniques, Network analysis, inventory theory and game theory.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 4 marks and section B of long answer type questions each carrying 8 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-Transportation problems: North-West Corner Method, Least-Cost Method, Vogel's Approximation method, MODI method.

Unit 2- Exceptional case and problem of degeneracy, Assignment problems.

Unit 3- Network Analysis, Constraints in Network, Construction of network, Critical Path Method (CPM) PERT, PERT Calculation, Resource Leveling by Network Techniques and advances of network (PERT/CPM). Simulation: Monte-Carlo Simulation.

Unit 4- Inventory theory: Inventory models on economic lot size system with uniform and non-uniform demand, Economic lot size with finite rate of replacement, A simple order level system with constant rate of demand with shortage, Generalized economic lot size model, Multi items deterministic models, Probabilistic model, Instantaneous demand, No setup cost model.

Unit 5- Game Theory- Two persons, Zero-sum games, Maximax-Minimax principle, Games without saddle points, Mixed Strategies, Graphical solution of 2 x m and m x 2 games, Solution by Linear programming, Non-linear programming techniques, Kuhn-Tucker Conditions, Non-negative constraints.

Recommended Books:

[1] Kanti Swarup, P.K.Gupta and Manmohan, Operations Research, Sultan Chand & Sons, New Delhi.

Reference Books:

[1] S. D. Sharma, Operations Research, Kedar Nath Ram Nath & Co., 1996.
[2] F.S. Hiller and G.J.Lieberman, Industrial Engineering Series,1995.
[3] G. Hadley, Linear Programming, Narosa Publishing House,1995.
[4] G. Hadley, Linear and Dynamic Programming, Addison-Wesley Reading Mass.
[5] H.A. Taha, Operations Research-An Introduction, Macmillan Publishing Co.Inc. New York.
[6] Prem Kumar Gupta and D.S.Hira, Operations Research-An Introduction, S.Chand & Sons Company Ltd.,New Delhi.
[7] N.S.Kambo, Mathematical Programming Technique, Affilated East West Pvt.Ltd.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Able to find optimal solution of transportation problem and assignment problem.

CO2: Able to distinguish transportation problem and assignment problem.

CO3: Understand the constructions of networks of a project and optimal scheduling using CPM and PERT.

CO4: Understand Inventory models on economic lot size system with uniform and non-uniform demand.

CO5: Able to formulate and solve linear programming model of two-person zero sum games.

M.Sc. MATHEMATICS
SEMESTER-IV
Paper Code: MAT-GE408 Advanced Discrete Mathematics– II

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: The objective of this course is to study directed graphs, Dijkstra's algorithm, Warshall's algorithm, Directed trees, Finite State Machines and their transition table diagrams, Finite Automata, Non-deterministic fine automata, Turing Machine and Partial recursive functions, Language generated by a grammar, Kleenes theorem, Polish Notations.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 6 marks and section B of long answer type questions each carrying 10 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1- Directed graphs, Indegree and outdegree of a vertex, Weighted undirected graphs, Dijkstra's algorithm, Strong connectivity, Warshall's algorithm, Directed trees, Search trees, Tree Traversals.

Unit 2- Introductory computability theorem-Finite State Machines and their transition table diagrams, Equivalence of finite State Machines, Reduced machines, homomorphism, Finite Automata, Acceptors.

Unit 3- Non-deterministic fine automata and equivalence of its power to that of deterministics, Finite automata, Moore and Mealy Machines.

Unit 4- Turing Machine and Partial recursive functions. Grammars and Languages- Phrase-structure grammars, Rewriting rules, Derivations.

Unit 5- Sentential forms, Language generated by a grammar, Regular, Context-free and Context sensitive grammars and Languages, regular sets, Regular expression and the Pumping lemma, Kleenes theorem. Notions of syntax analysis, Polish Notations, Conversion of infix expressions to Polish notation, The reverse Polish notation.

Recommended Books:

[1] J.P.Trambly and R. Manohar, Discrete Mathematical Structures with Application to Computer Science, McGraw-Hill book Co., 1997.

[2] N. Deo, Graph Theory with Application to Engineering and Computer Sci., Prentice Hall of India.

Reference Books:

[1] J.L. Gersting, Mathematical Structure for Computer Science (3rd Edition), Computer Science Press, New York.

[2] Seymour Lepschutz, Finite Mathematics (International Edition, 1983), McGraw Hill Co., New York.

[3] S.Wiitala, Discrete Mathematics-A Unified Approach, McGraw Hill Book Co.

[4] J.E. Hopcroft and J.D. Ullman, Introduction to Automata Theory Languages and Compulation, Narosa Publishing House.

[5] C.L. Liu, Elements of Discrete Mathematics, McGraw Hill Book Co.

Course Learning Outcomes: After studying this course the student will be able to:

CO1: Understand Directed graphs, weighted undirected graphs, Dijkstra's algorithm, Warshall's algorithm.

CO2: Able to work on Finite State Machines and their transition table diagrams.

CO3: Understand Non-deterministic fine automata, Finite automata, Moore and Mealy Machines.

CO4: Understand Turing Machine and Partial recursive functions, Grammars and Languages.

CO5: Understand Polish Notations, The reverse Polish notation.

M.Sc. MATHEMATICS
SEMESTER-IV
Paper Code: MAT-GE409
Cryptography

Credit: 4	Max. Marks	Min. Pass Marks
Theory	60	21
Cont. Evln.	40	14

Course Objectives: This course will provide students with a theoretical knowledge of cryptography and network security. By the end of the course, students should be able to:

- Understand the fundamental principles of access control models and techniques, authentication and secure system design.
- Have a strong understanding of different cryptographic protocols and techniques and be able to use them.
- Apply methods for authentication, access control, intrusion detection and prevention.
- Indentify and mitigate software security vulnerabilities in existing systems.

Note: The question paper will consist of two sections A & B. Section A will consist of short answer type questions each carrying 6 marks and section B of long answer type questions each carrying 10 marks. In each section there will be five questions, one from each unit with internal choice. All questions will be compulsory.

Unit 1-

Introduction to Cryptography, Security Threats, Vulnerability, Active and Passive attacks, Security services and mechanism, Conventional Encryption Model, CIA model.

Unit 2-

Modular Arithmetic, Euclidean and Extended Euclidean algorithm, Prime numbers, Fermat and Euler's Theorem.

Unit 3-

Classical Cryptography : Dimensions of Cryptography, Classical Cryptographic Techniques, Block Ciphers (DES, AES) : Feistal Cipher Structure, Simplifies DES, DES, Double and Triple DES, Block Cipher design Principles, AES, Modes of Operations.

Unit 4-

Public-Key Cryptography : Principles of Public-Key Cryptography, RSA Algorithm, Key Management, Diffie-Hellman Key Exchange, Elgamal Algorithm, Elliptic Curve Cryptography.

Unit 5-

Security in Networks : Threats in networks, Network Security Controls – Architecture, Encryption, Content Integrity, Strong Authentication, Access Controls, Wireless Security, Honeypots, Traffic flow security, Firewalls – Design and Types of Firewalls, Personal Firewalls, IDS, Email Security – PGP, S/MIME.

Recommended Books:

[1] William Stallings, Cryptography And Network Security Principles And Practice Fourth Edition , Pearson Education.
[2] Wenbo Mao, Modern Cryptography: Theory and Practice, Prentice Hall PTR.
[3] William Stallings, Network Security Essentials: Applications and Standards, Prentice Hall.
[4] Douglas R. Stinson, Cryptography: Theory and Practice, CRC press.

Course Learning Outcome: At the end of the course the students will be able to do:

CO1: Understand cryptography and network security concepts and application.

CO2: Apply security principles to system design.

CO3: Identify and investigate network security threat.

CO4: Analyze and design network security protocols.

CO5: Conduct research in network security.