RAMAKRISHNA MISSION VIVEKANANDA CENTENARY COLLEGE

RAHARA, KOLKATA-700118

DEPARTMENT OF MATHEMATICS

SESSION 2019-20

Syllabus for B.Sc. Mathematics Under CBCS

The course of B. Sc. Mathematics is modified under CBCS syllabus
vide BOS resolution dated 16.08.2019
with 25% modification

PROGRAM OUTCOMES

After completion of the B.Sc. Degree program, the students will be able to

PO No.	Program Outcomes	Cognitive Level
PO 1	Recognize the scientific tempers and attitudes, which in turn can prove to be beneficial for the society since the scientific developments can make a nation or society to grow at a rapid pace.	R
PO 2	Understand scientific knowledge and exchange ideas with other stakeholders; make people aware about sustainable utilization of resources with ethical approach.	U
PO 3	Understand and apply the issues of environmental contexts and sustainable development as a basic interdisciplinary concern.	U, Ap
PO 4	Create the ability to perform experiments and to analyse & interpret the obtained accurate results and thus gain the ability to solve problems, to involve in critical, independent, and creative thinking.	An, E, C
PO 5	Possess expertise to apply and formulate ideas which will provide them competitive advantage in pursuing higher studies from India or abroad; and seek jobs in academia, research or industries.	Ap, E
PO 6	Assemble the acquired in-depth knowledge of applied subjects towards the inculcation of professional and employment skills so that students can make a career and become an entrepreneur in diverse fields.	C

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

PROGRAMME SPECIFIC OUTCOMES

After the successful completion of this course, the student will be able to:

PSO No.	Program Specific Outcomes	Cognitive Level
PSO1	Explain the core ideas and the techniques of mathematics at the college level and recognize the power of abstraction and generalization, and to carry out investigative mathematical work with independent judgment.	R, U
PSO2	Set up mathematical models of real-world problems, obtain solutions in structured and analytical approaches, carry out objective analysis and prediction of quantitative information with independent judgment.	Ap
PSO3	Learn numerical aptitude applying both qualitative and quantitative knowledge for their future career and being a responsible citizen towards their community and a sustainable environment.	Ap, E
PSO4	Communicate to lay audiences and arouse their interest in the beauty and precision of mathematical arguments and science and recognize the importance of compliance with the ethics of science.	An, C
PSO5	Collaborate effectively in team work and team building, conduct self-evaluation, and continuously enrich themselves through lifelong learning.	C

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Course Structure: Semester-wise distribution of Courses
Honours

Semester -I		
Course Code	**Title**	**Credits**
UGAECC-I	English Communication	2
UGMATHCC01	Calculus, Geometry & Differential Equation & Practical	4+2
UGMATHCC02	Algebra & Tutorial	5+1
Semester-II		
UGAECC-II	Environmental Science (Envs)	2
UGMATHCC03	Real Analysis & Practical	4+2
UGMATHCC04	Differential Equations & Vector Calculus & Practical	5+1
Semester -III		
UGMATHCC05	Theory of Real Functions & Introduction to Metric Spaces	65+1
UGMATHCC06	Group Theory I & Tutorial	5+1
UGMATHCC07	Numerical Methods & Practical - Numerical Methods Lab	4 +2
Semester -IV		
UGMATHCC08	Riemann Integration and Series of Functions	5+1
UGMATHCC09	Multivariate Calculus	5+1
UGMATHCC10	Ring Theory and Linear Algebra I	5+1
Semester -V		
UGMATHCC11	Partial Differential Equations and Applications & Practical	4+2
UGMATHCC12	Group Theory II & Tutorial	5+1
Electives		
UGMATHDSE1	Linear Programming & Tutorial	5+1
UGMATHDSE2	Probability and Statistics & Tutorial	5+1
Semester -VI		
UGMATHCC13	Metric Spaces and Complex Analysis & Tutorial	5+1
UGMATHCC14	Ring Theory and Linear Algebra II & Tutorial	5+1
Electives Choose any two of the following courses		
UGMATHDSE3 UGMATHDSE4	1.Mechanics & Tutorial	5+1
	2.Bio Mathematics & Practical	4+2
	3.Point Set Topology & Tutorial	5+1
Skill Enhancement Subjects		
UGMATHSEC1	Logic and Sets	2
UGMATHSEC2	Python 3.4.3	2
Generic Elective Subjects Syllabus		
TOTAL		116
Generic Elective Subjects Syllabus		
UGMATHGE01	Algebra & Tutorial	5+1
UGMATHGE02	Calculus, Geometry and Differential Equation & Tutorial	5+1
UGMATHGE03	Numerical Methods & Tutorial	5+1
UGMATHGE04	Group Theory & Tutorial	5+1
TOTAL		24
GRAND TOTAL		**140**

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Semester-wise detailed syllabus

SEMESTER – I	
Name of the Course: **English Communication**	
Course Code: **UGAECC-I**	
Full Marks: 50	Credit: 2
Number of classes required: 90	

Course Objectives (UGAECC-I)

The prime objectives of the course are:

- In-depth knowledge of language skills – Listening, Speaking, Reading and Writing.
- In-depth knowledge of grammar and their applications in Speaking, Reading and Writing Skills.
- To provide expertise and consultancy services in the private and public sector and to be an entrepreneur/professional consultant.
- To opt for higher education, research and to be a life-long learner.
- To provide value based and ethical leadership to the profession and social life.

Course Content

Unit I: Introduction to Communication

- Process of Communication
- Levels of Communication
- Flow of Communication
- Verbal and Non-Verbal Communication
- Barriers to Communication

Unit II: Listening and Speaking Skills

- Listening and its types.
- Barriers to effective listening,
- Trials of a good listener.
- Introduction to English Phonetic Symbols: Consonants and Vowels with illustrations in use.
- Dialogue
- Group Discussion
- Presentation
- Interview Technique.

Unit III: Reading and Writing Skills

- Techniques of Reading

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- Types of Reading
- Reading Comprehension (unseen passage)
- Paragraph Writing
- Letter Writing
- Email Writing
- Report Writing
- Proposal writing
- Book Review
- Poster Making

Question Pattern for End Semester Examination (Course Code: UGAECC)

COMPONENT	NATURE OF THE QUESTION	MAXIMUM MARKS
Part A	Short answers	5 X 1 = 5 Marks
Part B	Listening	1 X 5 = 5 Marks
Part C	Speaking (Presentation and Project submission)	1 X 15 = 15 Marks
Part C	Reading Comprehension	1 X 5 = 5 Marks
Part C	Writing	2 X 5 = 10 Marks 1 X 10 = 10 Marks

Prescribed Books:

1. Vibrant English (New Delhi: Orient Black Swan)
2. Speak Well (New Delhi: Orient Black Swan) a compulsory supplementary Work Book for exercises on Interactions, dialogue, presentation skills, Group discussions, debates and Interviews.

Course Outcome (UGAECC-I)

By the end of the program, the students will be able to:

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Engage in self-directed English language learning.	R,	PO1, PO2, PO3	PSO 1
CO 2	Be responsible and ethical English users.	R, U	PO1, PO2, PO3	PSO 1
CO 3	Enhance their English language proficiency in the aspects of reading, writing, listening and speaking.	R, U	PO1, PO2, PO3	PSO 1
CO 4	Develop academic literacy required for undergraduate learning, further studies and research.	Ap	PO3, PO5	PSO 2
CO 5	Apply the requisite communicative skills and strategies to future careers.	Ap,	PO3, PO5	PSO 2
CO 6	Gain an insight into cultural literacy and cross-cultural awareness.	Ap	PO3, PO5	PSO 2

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Recommended Readings for advanced learning:

1. Advanced Skills in English. eds E Suresh Kumar et al..
2. Practising Writing Skills, Work Book
3. Enhancing English and Employability Skills
4. Business Communication,
5. English for Fluency
6. English Language Practice
7. Basics of Academic English- 1 and 2
8. Practising English- all these are Orient Black Swan publications

SEMESTER – I		
Name of the Course: **Calculus, Geometry & Differential Equation**		
Course Code: **UGMATHCC01**		
Full Marks: 100		Credit: 6
Theory	Credits: 4 Full Marks: 65	
Practical	Credits: 2 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 20%		

Course Objectives (UGMATHCC01)

The prime objectives of the course are:

- To introduce the students to the exciting world of differential equations, mathematical modelling and their applications.
- To evaluate integration of irrational functions and improper integrals.
- To understand the concepts of double and triple integration.
- Calculate definite integrals that may involve logarithms, exponentials, polynomials, and powers by using the Fundamental Theorem of Calculus.

Course Content

Calculus, Geometry & Differential Equation

Unit 1: Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}\sin x; e^{ax+b}\cos x; (ax+b)^n \sin x; (ax+b)^n \cos x.$

Pedal equation of a curve, pedal of a curve, curvature: Radius of curvature. Centre of curvature, evolute of a curve. Asymptotes, envelopes, concavity, convexity, singular points and inflection points, curve tracing in cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule.

[15]

Unit 2: Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\,dx, \int \cos^n x\,dx, \int \tan^n x dx, \int \sec^n x dx, \int (\log x)^n dx, \int \sin^n x \cos^m x\,dx,$

Working knowledge of Beta and Gamma function (convergence to be assumed) and their interrelation (no proof). Use of the result $\Gamma(n)\,\Gamma(1-n) = \pi$ where $0 < n < 1$. $\sin n\pi$

Using Beta function and Gamma function, compute the integrals: $\int_0^{\frac{\pi}{2}} \sin nx\,dx, \int_0^{\frac{\pi}{2}} \cos nx\,dx, \int_0^{\frac{\pi}{2}} \tan nx\,dx, \int_0^{\frac{\pi}{2}} \sin^m nx \cos^n mx\,dx.$ when they exist. Parametric equations, parameterizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution, techniques of sketching conics. [15]

Unit 3: Reflection properties of conics, rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics.

Spheres, cylindrical surfaces, central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid. [15]

Unit 4: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. Equations of first order but not of first degree. Clairaut's equation. Applications: Geometric applications, Orthogonal trajectories.

[15]

Unit 5: Practical (Using Any Software)

1. Plotting of graphs of function e^{ax+b}, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b),
2. |ax + b| and to illustrate the effect of a and b on the graph.
3. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
4. Sketching parametric curves (e.g. Trochoid, cycloid, epicycloids, hypo cycloid).
5. Obtaining surface of revolution of curves.
6. Tracing of conics in cartesian coordinates / polar coordinates.
7. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using cartesian coordinates. [30]

Question Pattern for End Semester Examination (Course Code: UGMATHCC01)

Unit-1 (Calculus, 12 marks)

1. Attempt 2 questions out of 3 questions and each question carries 2 marks = 2×2 = 4
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4= 8

Unit-2 (Calculus, 12 marks)

3. Attempt 2 questions out of 4 questions and each question carries 2 marks =2×2 = 4
4. Attempt 2 questions out of 4 questions and each question carries 4 marks =2×4= 8

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Unit-3 (Geometry, 12 marks)

5. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 = 4
6. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Unit-4 (Differential Equation, 14 marks)

7. Attempt 3 questions out of 4 questions and each question carries 2 marks = 2×3 = 6
8. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 = 8

Course Outcomes (UGMATHCC01)

After completing the course, students will be able to:

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSO Addressed
CO1	Recall the basic concepts of conics and classification of quadrics.	U, R	PO1, PO2, PO3	PSO1
CO2	Construct a variety of differential equations analytically and numerically.	Ap	PO3, PO5	PSO2
CO3	Measure/calculate length, perimeter, area, volume of surface of revolution of a curve and techniques of sketching conics.	Ap, E	PO3, PO4, PO5	PSO3
CO4	Develop ability to graphically analyze functions by computer practical.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C =creating

Reference Books:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India)
3. P. Ltd. (Pearson Education), Delhi, 2007.
4. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd.,Singapore, 2002.
5. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
6. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
7. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
8. G.F. Simmons, Differential Equations, Tata Mcgraw Hill.
9. T. Apostol, Calculus, Volumes I and II.
10. S. Goldberg, Calculus and mathematical analysis.

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SEMESTER – I		
Name of the Course: **Algebra**		
Course Code: **UGMATHCC02**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%		

Course Objectives (UGMATHCC02)

The prime objectives of the course are:

- To introduce the basic tools of theory of equations, complex numbers, number theory and matrices.
- To understand the connection of algebra with the real-world problems.
- Perform matrix algebra with applications to computer graphics.
- Learn to solve systems of linear equations and application problems requiring them.

Course Content

Algebra

Unit 1: Complex Numbers: De-Moivre's Theorem and its applications, Exponential, Sine, Cosine and Logarithm of a complex number. Definition of a^z ($a \neq 0$). Inverse circular and Hyperbolic functions.

Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, cubic and biquadratic equation. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic.

Inequality: The inequality involving AM ≥ GM ≥ HM, Cauchy-Schwartz inequality. [30]

Unit 2: Equivalence relations. Functions, composition of functions, Invertible functions, one to one correspondence and cardinality of a set.

Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical induction, statement of Fundamental Theorem of Arithmetic. The greatest common divisor (g.c.d.) of two integers a and b. Existence and uniqueness of (a, b). Relatively prime integers. The equation ax + by = c has integral solution iff (a, b) divides c. (a, b, c are integers). Prime integers. Euclid's first theorem: If some prime p divides ab, then p divides either a or b.

Euclid's second theorem: There are infinitely many prime integers. Congruences, Linear Congruences. Statement of Chinese Remainder Theorem and simple problems, Theorem of Fermat. [20]

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Unit 3: Systems of linear equations, row reduction and echelon forms, the matrix equation Ax = b, solution sets of linear systems, applications of linear systems, linear independence. [15]

Unit 4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of Rn, dimension of subspaces of Rn, rank of a matrix, Eigen values, eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix. [25]

Question Pattern for End Semester Examination (Course Code: UGMATHCC02)

Unit-1 (Algebra, 12 marks)

1. Attempt 2 questions out of 3 questions and each question carries 2 marks = 2×2 = 4
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4= 8

Unit-2 (Algebra, 14 marks)

3. Attempt 3 questions out of 4 questions and each question carries 2 marks = 2×3 = 6
4. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 = 8

Unit-3 (Algebra, 12 marks)

5. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 = 4
6. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Unit-4 (Algebra, 12 marks)

7. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 = 4
8. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Course Outcomes (UGMATHCC02)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Understand complex numbers, way of representing numbers, relationships among numbers, different method for solving polynomial equations.	Ap	PO3, PO5	PSO2
CO2	Solve linear equations.	Ap	PO3, PO5	PSO2
CO3	Demonstrate their ability to graphically or numerically analyze functions by presentation.	C	PO4, PO6	PSO5

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Recommended Books

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph

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Theory,3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia,Indian Reprint, 2007.
4. K.B. Dutta, Matrix and linear algebra.
5. K. Hoffman, R. Kunze, Linear algebra.
6. W.S. Burnstine and A.W. Panton, Theory of equations.
7. Barnard and Child, Higher Algebra.
8. S. K. Mapa, Higher Algebra (Classical, Abstract& Linear).
9. Surjeet Singh and Qazi Zameruddin , Modern Algebra.
10. D.S. Dummit and R. M. Foote, Abstract Algebra.
11. M. Artin , Algebra.
12. I. N. Herstein, Topics in Algebra.
13. M. K. Sen, S. Ghosh, P. Mukhopadhyay, Topics in Abstract Algebra.

SEMESTER – II		
Name of the Course: **ENVIRONMENTAL SCIENCE (ENVS)**		
Course Code: **UGAECC-II**		
Full Marks: 50		Credit: 2
Theory	Credits: 2 Full Marks: 60	
Number of classes required: 60		

Course Objectives:

After completion of this course the student will be able to

CO No.	Course Objectives:
CO 1:	Remembers and understands the concept, components and function of natural resources and ecosystems.
CO 2:	Understand and evaluate the Cause, effects and control measures of various environmental pollutants.
CO 3:	Understand the basic idea about the disasters and its management.
CO 4:	Understand and apply the knowledge about the social, environmental issues and environmental legislation.

1. **Definition**, scope and importance. Need for public awareness. (2 lectures)
2. **Natural Resources: Renewable and non-renewable**: Forest, Water, Mineral, Food, Energy & Land resources – Use and associated problems. (8 lectures)
3. **Ecosystems:** Concept, Structure and function, Energy flow, Ecological succession, Food chains, food webs and ecological pyramids. Types – Forest, Grassland, Desert & Aquatic (ponds, streams, lakes, rivers, oceans, estuaries) ecosystems. (12 lectures)
4. **Environmental Pollution:** Definition, Cause, effects and control measures of - Air, Water, Soil, Noise pollution and Nuclear hazards. Solid waste Management. Role of an individual in prevention of pollution. (10 lectures)

5. **Disasters and management**: Floods, Earthquake, Cyclone and Landslides. (4 lectures)
6. **Social Issues and the Environment:** Water conservation, rain water harvesting, watershed management. Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation. Consumerism and waste products. Urban problems related to energy. (10 lectures)
7. **Environmental legislation:** Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Issues involved in enforcement of environmental legislation. Public awareness. (8 lectures)
8. **Human Population and the Environment:** Population growth, variation among nations; Population explosion – Family Welfare Programme; Environment and human health (including HIV/AIDS); Human Rights; Role of Information Technology in Environment and human health. (6 lectures)

Course Outcomes:

After completion of this course the student will be able to

CO No.	Course Outcomes:	Cognitive Level	PO Addressed	PSOs Addressed
CO 1:	Define and demonstrate the concept, components and function of natural resources and ecosystems.	R, U	PO1	PSO1
CO 2:	Define, illustrate and analyse the cause, effects and control measures of various environmental pollutants.	R, U, An	PO 3	PSO1, PSO4
CO 3:	Demonstrate the basic idea about the disasters and its management.	U	PO 3	PSO1
CO 4:	Illustrate and apply the knowledge about the social, environmental issues and environmental legislation.	U, Ap	PO 4	PSO1, PSO2
CO 5:	Define, demonstrate and evaluate the impact of human population on the Environment	R, U, E	PO 6	PSO1, PSO3

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References:

1. Agarwal KC, 2001. Environmental Biology, Nidi Publishers Ltd. Bikaner.
1. Bharucha Erach, 2003. The Biodiversity of India, Mapin Publishing Pvt. Ltd, Ahmedabad – 380013, India. Email: mapin@icenet.net
2. Brunner RC, 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480pgs.
3. Clark RS, Marine Pollution, Clanderson Press, Oxofrd (TB).
4. Cunningham WP, Cooper TH, Gorhani E & Hepworth MT, 2001. Environmental Encyclopaedia, Jaico Publishing House, Mumbai, 1196pgs.
5. De AK, Environmental Chemistry, Wiley Eastern Ltd.
6. Down to Earth, Center for Science and Environment (R)
7. Gleick HP, 1993. Water in Crisis, Pacific Institute for Studies in Development, Environment and Security. Stockholm Environmental Institute, Oxford University Press, 473pgs.
8. Hawkins RE, Encyclopaedia of Indian Natural History, Bombay Natural History Society, Bombay (R)
9. Heywood V H and Watson R T, 1995. Global Biodiversity Assessment. Cambridge University Press 1140pgs.
10. Jadhav H and Bhosale VM, 1995. Environmental Protection and Laws. Himalaya Publishing House, Delhi 284pgs.
11. Mckinney ML and Schoch RM, 1996. Environmental Science Systems and Solutions. Web enhanced edition, 639pgs.
12. Mhaskar AK, Matter Hazardous, Techno-Science Publications (TB)
13. Miller TG, Jr. Environmental Science, Wadsworth Publishing CO. (TB)
14. Odum EP, 1971. Fundamentals of Ecology. WB Saunders Co. USA, 574pgs.
15. Rao MN and Datta AK, 1987. Waste Water Treatment. Oxford and IBH Publishing Co. Pvt. Ltd. 345pgs.

SEMESTER – II		
Name of the Course: **Real Analysis**		
Course Code: **UGMATHCC03**		
Full Marks: 100		Credit: 6
Theory	Credits: 4 Full Marks: 65	
Practical	Credits: 2 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019; 25%		

Course Objectives (UGMATHCC03)

The prime objectives of the course are:

- To develop a deep and rigorous understanding of real line R.
- Define terms to prove the results about convergence and divergence of sequences and series of real numbers.
- To understand the concept of sets and elements, Definition of a sequence and subsequence.
- To introduce the concepts for understanding and analyzing abstract mathematics on the metric space.

Course Content

Real Analysis

Unit 1: Review of algebraic and order properties of R, ε-neighborhood of a point in R. Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima. Completeness property of R and its equivalent properties. The Archimedean property, density of rational (and Irrational) numbers in R, intervals. Limit points of a set, isolated points, open set, closed set, derived set, illustrations of Bolzano-Weierstrass theorem for sets, compact sets in R, Heine-Borel Theorem.

[20]

Unit 2: Sequences, bounded sequence, convergent sequence, limit of a sequence, lim inf, limsup. Limit theorems. Monotone sequences, monotone convergence theorem. Sub sequences, divergence criteria. Monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion. [20]

Unit 3: Infinite series, convergence and divergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, ratio test, Cauchy's nth root test, integral test. Alternating series, Leibniz test. Absolute and conditional convergence. [20]

Practical

Unit 4: (Using Any Software)

- Plotting of recursive sequences.
- Study the convergence of sequences through plotting.

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- ❖ Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent sub sequences from the plot.
- ❖ Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
- ❖ Cauchy's root test by plotting nth roots.
- ❖ Ratio test by plotting the ratio of nth and (n+1)th term.

[30]

Question Pattern for End Semester Examination (Course Code: UGMATHCC03)

Unit-1 (Real Analysis, 16 marks)

1. Attempt 2 questions out of 3 questions and each question carries 2 marks = 2×2 = 4
2. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4= 12

Unit-2 (Real Analysis, 18 marks)

3. Attempt 3 questions out of 4 questions and each question carries 2 marks = 2×3 = 6
4. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-3 (Real Analysis, 16 marks)

5. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 = 4
6. Attempt 3 questions out of 4 questions and each question carries 4 marks =3×4=12

Course Outcomes (UGMATHCC03)

After completing the course, students will be able to:

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Describe the real line as a complete, ordered field.	U	PO1, PO2, PO3	PSO1
CO 2	Use the definitions of convergence as they apply to sequences, and series.	R, Ap	PO3, PO5	PSO2
CO 3	Determine the basic topological properties of subsets of the real numbers.	E	PO3, PO4, PO5	PSO3
CO 4	Plot the convergence of sequences and series of different test on computer.	An, E	PO4, PO6	PSO4

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones& Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
4. S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House.

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6. Courant and John, Introduction to Calculus and Analysis, Vol I, Springer
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
8. Terence Tao, Analysis I, Hindustan Book Agency, 2006.
9. S. Goldberg, Calculus and mathematical analysis.
10. S. C. Malik and Arora, Mathematical Analysis.

SEMESTER – II		
Name of the Course: **Differential Equations & Vector Calculus**		
Course Code: **UGMATHCC04**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 22%		

Course Objectives (UGMATHCC04)

- The main objective of this course is to introduce the students to the exciting world of differential equations, mathematical modeling and their applications.
- Evaluate first order differential equations including separable, homogeneous, exact, and linear.
- Show existence and uniqueness of solutions.
- Solve second order and higher order linear differential equations.
- Create and analyze mathematical models using higher order differential equations to solve application problems such as harmonic oscillator and circuits.

Course Content

Differential Equations & Vector Calculus

Unit 1: Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non- homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters. [25]

Unit 2: Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients,
Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. [20]

Unit 3: Equilibrium points, Interpretation of the phase plane, nature of equilibrium point. Power series solution of a differential equation about an ordinary point, solution about a regular singular point. [10]

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Unit 4: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.

[20]

Practical

Unit 5: (Using Any Software)

- Plotting of family of curves which are solutions of second order differential equation.
- Plotting of family of curves which are solutions of third order differential equation.

[15]

Question Pattern for End Semester Examination (Course Code: UGMATHCC04)

Unit-1 (Differential Equations, 15 marks)

1. Attempt 3 questions out of 4 questions and each question carries 5 marks = 3×5 =15

Unit-2 (Differential Equations, 10 marks)

2. Attempt 1 questions out of 2 questions and each question carries 2 marks = 1×2 = 2
3. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 = 8

Unit-3 (Differential Equations, 15 marks)

4. Attempt 3 questions out of 4 questions and each question carries 5 marks =3×5 = 15

Unit-4 (Vector Calculus, 10 marks)

5. Attempt 1 questions out of 2 questions and each question carries 2 marks =1×2 =2
6. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Course Outcomes (UGMATHCC04)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Find general solution of homogenous and non-homogenous equation of higher order and their super position.	R	PO1, PO2, PO3	PSO1
CO 2	Find power series solutions of differential equations, and develop the ability to apply differential equations to significant applied and/or theoretical problems.	R, Ap	PO3, PO5	PSO2
CO 3	Describe Euler's equation, method of undetermined coefficients and method of variation of parameters.	E	PO3, PO4, PO5	PSO3
CO 4	Analyse vector functions (graphically or analytically) to find derivatives, tangent lines, integrals, arc length, and curvature.	An	PO4, PO6	PSO4
CO 5	Demonstrate their understanding of how physical phenomena are modelled by differential equations and	C	PO4, PO6	PSO5

	dynamical systems. Implement solution methods using appropriate technology.			

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.
2. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
3. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
4. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
5. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
6. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.
7. G.F.Simmons, Differential Equations, Tata McGraw Hill
8. Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
9. Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
10. M.R. Speigel, Schaum's outline of Vector Analysis.

SEMESTER – III	
Name of the Course: **Theory of Real Functions & Introduction to Metric Spaces**	
Course Code: **UGMATHCC05**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 65
Tutorial	Credits: 1 Full Marks: 35
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 30%	

Course Objectives (UGMATHCC05)

The prime objectives of the course are:

- To study the real valued functions that would develop an analytical ability to have a more matured perspective of the key concepts of calculus, namely, limits, continuity, differentiability and their applications.
- Understand the concepts of analysis which evidently rely on the notion of distance.
- To develop the usual idea of distance into an abstract form on any set of objects, maintaining its inherent characteristics, and the resulting consequences.

Course Content

Theory of Real Functions & Introduction to Metric Spaces

Unit I: Limits of functions (ε - δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity.
Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem. [25]

Unit 2: Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials. [20]

Unit 3: Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1 + x)$, $1/(ax + b)$ and $(x+1)^n$. Application of Taylor's theorem to inequalities. [20]

Unit4: Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces. [20]

Question Pattern for End Semester Examination (Course Code: UGMATHCC05)

Unit-1 (Theory of Real Functions, 14 marks)

1. Attempt 3 questions out of 4 questions and each question carries 2 marks = 3×2 =6
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-2 (Theory of Real Functions, 10 marks)

3. Attempt 1 questions out of 2 questions and each question carries 2 marks = 1×2 = 2
4. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 = 8

Unit-3 (Theory of Real Functions, 14 marks)

5. Attempt 3 questions out of 4 questions and each question carries 2 marks =3×2 = 6
6. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×4 = 8

Unit-4 (Introduction to Metric Spaces, 12 marks)

7. Attempt 2 questions out of 4 questions and each question carries 2 marks =2×2 =4
8. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

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Course Outcomes (UGMATHCC05)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Understand the sequential approaches of limit, continuity, uniform continuity and some important properties.	U	PO1, PO2, PO3	PSO1
CO 2	Recognize the difference between pointwise and uniform convergence of a sequence of functions	R	PO1, PO2, PO3	PSO1
CO 4	Recall the defining properties of a metric space, and determine whether a given function defines a metric and get familiarize with open sets, closed sets and Cantor set.	R, U	PO1, PO2, PO3	PSO1
CO 3	Apply the Mean Value Theorem and the Fundamental Theorem of Calculus to problems in the context of real analysis.	Ap, E	PO3, PO4, PO5	PSO3

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House
6. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
8. Terence Tao, Analysis II, Hindustan Book Agency, 2006
9. SatishShirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006
10. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
11. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

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SEMESTER – III	
Name of the Course: **Group Theory I**	
Course Code: **UGMATHCC06**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 65
Tutorial	Credits: 1 Full Marks: 35
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%	

Course Objectives (UGMATHCC06)

The prime objectives of the study are:

- To introduce the fundamental theory of groups and their homomorphisms.
- Understand the symmetric groups and group of symmetries.
- Understand the Fermat's Little theorem as a consequence of the Lagrange's theorem on finite groups.

Course Content

Group Theory I

Unit1: Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups. [15]

Unit 2: Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. [10]

Unit 3: Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. [25]

Unit 4: External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups. [15]

Unit 5: Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems. [25]

Question Pattern for End Semester Examination (Course Code: UGMATHCC06)

Unit-1 (Group Theory I, 6 marks)

1. Attempt 1 questions out of 2 questions and each question carries 2 marks = 1×2 =2
2. Attempt 1 questions out of 2 questions and each question carries 4 marks = 1×4 =4

Unit-2 (Group Theory I, 6 marks)

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3. Attempt 1 questions out of 2 questions and each question carries 2 marks = 1×2 =2
4. Attempt 1 questions out of 2 questions and each question carries 4 marks = 1×4 =4

Unit-3 (Group Theory I, 14 marks)

5. Attempt 3 questions out of 4 questions and each question carries 2 marks =3×2 = 6
6. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×4 = 8

Unit-4 (Group Theory I, 12 marks)

7. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 =4
8. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Unit-5 (Group Theory I, 12 marks)

9. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 =4
10. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Course Outcomes (UGMATHCC06)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Understand the External direct product of a finite groups, finite abelian groups and Cauchy's theorem.	U	PO1, PO2, PO3	PSO1
CO2	Understand and classify the permutation of a group, centre of a group, Lagrange's theorem and Fermat's Little theorem.	U, An	PO4, PO6	PSO4
CO3	Apply different properties of group homomorphisms and isomorphisms theorems and Cayley's theorem in solving problems.	Ap, C	PO4, PO6	PSO4
CO4	Develop the ability to graphically or mathematically analyse the different theorem on Group by presentation.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
6. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

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SEMESTER – III	
Name of the Course: **Numerical Methods**	
Course Code: **UGMATHCC07**	
Full Marks: 100	Credit: 6
Theory	Credits: 4 Full Marks: 65
Practical	Credits: 2 Full Marks: 35
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%	

Course Objectives (UGMATHCC07)

The prime objectives of the course are:

- To develop an understanding of the elements of error analysis for numerical methods and certain proofs.
- The main objective of this course is to provide students with an introduction to the field of numerical analysis.
- Derive appropriate numerical methods to solve problems based on interpolation.
- Derive appropriate numerical methods to solve problems based on probability.
- Prove results for various numerical root finding methods.

Course Content

Numerical Methods

Unit 1: Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation. [2]

Unit 2: Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods. [10]

Unit 3: System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition. [10]

Unit 4: Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Numerical differentiation: Methods based on interpolations, methods based on finite differences. [13]

Unit 5: Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. Midpoint rule, Composite trapezoidal rule, composite Simpson's 1/3rdrule, Gauss quadrature formula. The algebraic eigen value problem: Power method. Approximation: Least square polynomial approximation. [15]

Unit 6: Ordinary differential equations: The method of successive approximations, Picard's method, Taylor series method of successive approximation. Euler's method, the modified Euler

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method, Runge-Kutta methods of orders two and four. [10]

Unit -7: Practical - Numerical Methods Lab List of practical (using any software)

- Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + + 1/ N.
- Enter 100 integers into an array and sort them in an ascending order.
- Solution of transcendental and algebraic equations by
- Bisection method
- Newton Raphson method.
- Secant method.
- Regula Falsi method.

- Solution of system of lineqwaar equations
- LU decomposition method
- Gaussian elimination method
- Gauss-Jacobi method
- Gauss-Seidel method

- Interpolation
- Lagrange Interpolation
- Newton Interpolation
- Numerical Integration
- Trapezoidal Rule
- Simpson's one third rule
- Weddle's Rule
- Gauss Quadrature
- Method of finding Eigenvalue by Power method
- Fitting a Polynomial Function
- Solution of ordinary differential equations
- Euler method
- Modified Euler method
- Runge Kutta method

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

Question Pattern for End Semester Examination (Course Code: UGMATHCC07)

Unit-1 (Numerical Methods, 2 marks)

1. Attempt 1 questions out of 2 questions and each question carries 2 marks = 1×2 =2

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Unit-2 (Numerical Methods, 10 marks)

2. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×5 =10

Unit-3 (Numerical Methods, 6 marks)

3. Attempt 1 question out of 1 question and each question carries 1 mark =1×1 = 1
4. Attempt 1 questions out of 2 questions and each question carries 5 marks =1×5 = 5

Unit-4 (Numerical Methods, 10 marks)

5. Attempt 2 questions out of 3 questions and each question carries 5 marks =2×5 =10

Unit-5 (Numerical Methods, 12 marks)

6. Attempt 1 questions out of 2 questions and each question carries 1 mark =1×2 =2
7. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×5= 10

Unit-6 (Numerical Methods, 10 marks)

8. Attempt 2 questions out of 3 questions and each question carries 5 marks =2×5 =10

Course Outcomes (UGMATHCC07)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Implement a variety of numerical algorithms using appropriate technology.	R, U	PO1, PO2, PO3	PSO1
CO 2	Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation.	E	PO3, PO4, PO5	PSO3
CO 3	Analyse the error incumbent in any such numerical approximation.	An	PO4, PO6	PSO4
CO 4	Understand graphically or numerically analyse the different methods of Numerical method by computer practical.	U, An	PO4, PO6	PSO4
CO 5	Numerical differentiate and integrate, solution of linear systems using different method.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering
3. Computation, 6th Ed., New age International Publisher, India, 2007.

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4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
8. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.

SEMESTER – IV		
Name of the Course: **Riemann Integration and Series of Functions**		
Course Code: **UGMATHCC08**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 20%		

Course Objectives (UGMATHCC08)

The prime objectives of the course are:

- To understand the integration of bounded functions on a closed and bounded interval and its extension to the cases where either the interval of integration is infinite, or the integrand has infinite limits at a finite number of points on the interval of integration.
- To understand the sequence and series of real valued functions, and an important class of series of functions (i.e., power series).

Course Content

Riemann Integration and Series of Functions

Unit1: Riemann integration: inequalities of upper and lower sums, Darbaux integration, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two definitions. Riemann integrability of monotone and continuous functions, properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorem of Integral Calculus. Function defined by definite integral $\int_a^x f(t)dt$ and its properties. Primitive or Indefinite Integral. Properties of definite integral. Definition of log x (x > 0) as an integral and deduction of simple properties including its range. Definition of e and its simple properties.
First Mean Value Theorem of Integral Calculus. Statements and applications of Second Mean Value Theorem of Integral Calculus (both Bonnett's form and Weierstrass form) Theorem on method of substitution for continuous functions. [25]

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Unit2: Improper integrals. Convergence of Beta and Gamma functions. [5]

Unit3: Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test. [20]

Unit4: Fourier series: Definition of Fourier coefficients and series, Reimann Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions and summation results for series. [20]

Unit5: Power series, radius of convergence, Cauchy Hadamard theorem. Differentiation and integration of power series; Abel's theorem; Weierstrass approximation theorem. [20]

Question Pattern for End Semester Examination (Course Code: UGMATHCC08)

Unit-1 (Riemann Integration, 15 marks)

1. Attempt 3 questions out of 4 questions and each question carries 5 marks = 3×5 =15

Unit-2 (Riemann Integration, 5 marks)

2. Attempt 1 questions out of 2 questions and each question carries 2 marks = 1×2 =2
3. Attempt 1 questions out of 2 questions and each question carries 3 marks = 1×3 =3

Unit-3 (Riemann Integration, 10 marks)

4. Attempt 1 questions out of 2 questions and each question carries 2 marks =1×2 = 2
5. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×4 = 8

Unit-4 (Riemann Integration, 10 marks)

6. Attempt 1 questions out of 2 questions and each question carries 2 marks =1×2 =2
7. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Unit-5 (Series of Functions, 10 marks)

8. Attempt 1 questions out of 2 questions and each question carries 2 marks =1×2 =2
9. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

Course Outcomes (UGMATHCC08)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Develop a knowledge about Riemann Integration, Fourier series and Power series, hence their properties and applications.	U	PO1, PO2, PO3	PSO1

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CO 2	Recognize the difference between pointwise and uniform convergence of a sequence of functions.	R	PO1, PO2, PO3	PSO1
CO 3	Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability.	U	PO1, PO2, PO3	PSO1
CO 4	Demonstrate graphically or analytically analyse integrability conditions, the sequence of functions, series of functions and their natures by presentation.	U, Ap	PO3, PO5	PSO2

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
4. S. Goldberg, Calculus and mathematical analysis.
5. Santi Narayan, Integral calculus.
6. T. Apostol, Calculus I, II.

SEMESTER – IV		
Name of the Course: **Multivariate Calculus**		
Course Code: **UGMATHCC09**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 20%		

Course Objectives (UGMATHCC09)

The prime objectives of the course are:

- To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables.
- Expertise the students to make use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.
- To become aware of applications of multivariable calculus tools in physics, economics, optimization.
- Understand the architecture of curves and surfaces in plane and space, etc.

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Course Content

Multivariate Calculus

Unit1: Functions of several variables, limit and continuity of functions of two or more variables. Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems [30]

Unit2: Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals. [25]

Unit3: Definition of vector field, divergence and curl. Line integrals, applications of line integrals: mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path. [15]

Unit4: Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem. [20]

Question Pattern for End Semester Examination (Course Code: UGMATHCC09)

Unit-1 (Multivariate Calculus, 13 marks)

1. Attempt 1 question out of 1 question and each question carries 1 mark = 1×1 =1
2. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-2 (Multivariate Calculus, 12 marks)

3. Attempt 2 questions out of 3 questions and each question carries 2 marks = 2×2 =4
4. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-3 (Multivariate Calculus, 13 marks)

5. Attempt 1 question out of 1 question and each question carries 1 mark =1×1 = 1
6. Attempt 3 questions out of 4 questions and each question carries 4 marks =3×4 =12

Unit-4 (Multivariate Calculus, 12 marks)

7. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 =4
8. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4= 8

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Course Outcomes (UGMATHCC09)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO1	Evaluate double and triple integrals over rectangular and non-rectangular region and volume by triple integrals in cylindrical and spherical coordinates.	E	PO3, PO4, PO5	PSO3
CO2	Demonstrate their ability to graphically or numerically analyze Partial differentiation, condition for differentiability relation between divergence theorem by presentation.	Ap, E	PO3, PO4, PO5	PSO3
CO3	Analyze the fundamental theorem of calculus and see their relation in calculus, leading to the more generalized version of Stokes' theorem in the setting of differential forms.	U, An	PO4, PO6	PSO4
CO4	Analyze functions of several variables to find limit, continuity and differentiability.	An	PO4, PO6	PSO4
CO5	Differentiate vector fields, determine gradient vector fields and find potential functions.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
4. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001
5. T. Apostol, Mathematical Analysis, Narosa Publishing House
6. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
8. Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
9. Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
10. Terence Tao, Analysis II, Hindustan Book Agency, 2006
11. M.R. Speigel, Schaum's outline of Vector Analysis.

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SEMESTER – IV	
Name of the Course: **Ring Theory and linear Algebra I**	
Course Code: **UGMATHCC10**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 65
Tutorial	Credits: 1 Full Marks: 35
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 20%	

Course Objectives (UGMATHCC10)

The prime objectives of the course are:

- To understand the Ring theory and domain.
- To introduce the fundamental theory of two objects, namely - rings and vector spaces, and their corresponding homomorphisms.
- To determine the eigen values and eigen vectors.
- To understand the concept of Algebra of linear transformations and matrices.

Course Content

Ring Theory and Linear Algebra I

Unit1: Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. [25]

Unit2: Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients. [20]

Unit3: Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. [20]

Unit4: Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix. [25]

Question Pattern for End Semester Examination (Course Code: UGMATHCC10)

Unit-1 (Ring Theory, 12 marks)

1. Attempt 2 questions out of 3 question and each question carries 2 marks = 2×2 =4
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

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Unit-2 (Ring Theory, 10 marks)

3. Attempt 1 question out of 2 questions and each question carries 2 marks = 1×2 =2
4. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-3 (Linear Algebra I, 14 marks)

5. Attempt 1 question out of 1 question and each question carries 2 marks =1×2 = 2
6. Attempt 3 questions out of 4 questions and each question carries 4 marks =3×4 =12

Unit-4 (Linear Algebra I, 14 marks)

7. Attempt 1 questions out of 2 questions and each question carries 2 marks =1×2 =2
8. Attempt 3 questions out of 4 questions and each question carries 4 marks =3×4= 12

Course Outcomes (UGMATHCC10)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Assess properties implied by the definitions of rings, factor rings, prime and maximal ideals.	U, Ap	PO3, PO5	PSO2
CO 2	Use the concepts of isomorphism and homomorphism for rings.	Ap	PO3, PO5	PSO2
CO 3	Use the definition and properties of linear transformations and matrices of linear transformations and change of basis, including kernel, range and isomorphism.	R, Ap	PO3, PO5	PSO2
CO 4	Analyse and demonstrate examples of ideals and quotient rings.	An, E	PO4, PO6	PSO4
CO 5	Demonstrate graphically or analytically analyze prime and maximal ideals, homomorphism and isomorphism theorem on rings and vector spaces by presentation.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.

7. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
8. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
10. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

SEMESTER – V		
Name of the Course: **Partial Differential Equations and Applications**		
Course Code: **UGMATHCC11**		
Full Marks: 100		Credit: 6
Theory	Credits: 4 Full Marks: 65	
Practical	Credits: 2 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 40%		

Course Outcomes (UGMATHCC11)

The prime objectives of the course are:

- To form and solve partial differential equations and use them in solving some physical problems.
- To derive heat and wave equations in 2D and 3D.
- Find the solutions of PDEs are determined by conditions at the boundary of the spatial domain and initial conditions at time zero.
- Understand the technique of separation of variables to solve PDEs and analyze the behaviour of solutions in terms of eigen function expansions.

Course Content

Partial Differential Equations and Applications

Unit1: Partial differential equations – Basic concepts and definitions. Mathematical problems. First- order equations: classification, construction and geometrical interpretation. Method of characteristics for obtaining general solution of quasi linear equations. Canonical forms of first-order linear equations. Method of separation of variables for solving first order partial differential equations. [15]

Unit2: Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order linear equations to canonical forms. [15]

Unit3: The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string. Initial boundary value problems. Semi-infinite string with a fixed end, semi- infinite string with a free end. Equations with non-homogeneous boundary conditions. Non-homogeneous wave equation. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem. [15]

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Unit4: Central force. Constrained motion, varying mass, tangent and normal components of acceleration, modelling ballistics and planetary motion, Kepler's second law. [15]

Practical

Unit 5: (Using Any Software)

1. Solution of Cauchy problem for first order PDE.
2. Finding the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

$$u(x,0) = \phi(x), u_t(x,0) = \psi(x), x \in R, t > 0.$$

$$u(x,0) = \phi(x), u_t(x,0) = \psi(x), u(0,t) = 0, x \in (0,\infty), t > 0.$$

5. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

$u(x,0) = \phi(x), u(0,t) = a, u(l,t) = b, x \in (0,l), t > 0.$

$u(x,0) = \phi(x), x \in R, 0 < t < T.$ [30]

Question Pattern for End Semester Examination (Course Code: UGMATHCC11)

Unit-1 (Partial Differential Equations, 14 marks)

1. Attempt 2 questions out of 3 question and each question carries 2 marks = 2×2 =4
2. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×5 =10

Unit-2 (Partial Differential Equations, 10 marks)

3. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×5 =10

Unit-3 (Partial Differential Equations, 14 marks)

4. Attempt 2 questions out of 3 questions and each question carries 7 marks =2×7 =14

Unit-4 (Partial Differential Equations, 12 marks)

5. Attempt 1 questions out of 2 questions and each question carries 2 marks =1×2 =2
6. Attempt 2 questions out of 3 questions and each question carries 5 marks =2×5=10

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Course Outcomes (UGMATHCC11)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Be familiar with the modelling assumptions and derivations that lead to PDEs.	Ap	PO3, PO5	PSO2
CO 2	Recognize the major classification of PDEs and the qualitative differences between the classes of equations.	U, An	PO4, PO6	PSO4
CO 3	Demonstrate graphically or analytically analyze the solution of Cauchy problem, characteristic for PDE and solution of Heat equation by python languages.	An, C	PO4, PO6	PSO4
CO 4	Be competent in solving linear PDEs using classical solution methods.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, Differential equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
4. Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill.
5. Miller, F. H., Partial Differential Equations, John Wiley and Sons.
6. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press

SEMESTER – V		
Name of the Course: **Group Theory II**		
Course Code: **UGMATHCC12**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 20%		

Course Objectives (UGMATHCC12)

The prime objectives of the course are:

- To develop an in-depth understanding of one of the most important branch of the abstract algebra with applications to practical real-world problems.
- Understand the classification of all finite abelian groups.
- Understand Sylow Theorems, Cauchy's theorem and simplicity of An for n ≥5.

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Course Content

Group Theory II

Unit1: Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties. [25]

Unit2: Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental theorem of finite abelian groups. [20]

Unit3: Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions. Generalized Cayley's theorem. Index theorem. [20]

Unit4: Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of An for $n \geq 5$, non-simplicity tests. [25]

Question Pattern for End Semester Examination (Course Code: UGMATHCC12)

Unit-1 (Group Theory II, 14 marks)

1. Attempt 3 questions out of 4 question and each question carries 2 marks = 3×2 =6
2. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×4 =8

Unit-2 (Group Theory II, 10 marks)

3. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
4. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×4 =8

Unit-3 (Group Theory II, 14 marks)

5. Attempt 3 questions out of 4 question and each question carries 2 marks = 3×2 =6
6. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×4 =8

Unit-4 (Group Theory II, 12 marks)

7. Attempt 2 questions out of 3 questions and each question carries 2 marks =2×2 =4
8. Attempt 2 questions out of 3 questions and each question carries 4 marks =2×4=8

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Course Outcomes (UGMATHCC12)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Explain the concept of group homomorphism, isomorphism and automorphism.	U, E	PO3, PO4, PO5	PSO3
CO 2	Infer the properties of external and internal direct product and fundamental theorem of finite abelian groups, conjugates, the Class Equation, p-groups, Cayley's theorem and Sylow's theorems.	An	PO4, PO6	PSO4
CO 3	Derive and apply Sylow Theorems, Cauchy's theorem and simplicity of An for $n \geq 5$.	An, E	PO4, PO6	PSO4
CO 4	Design graphically or analytically analyse the application of factor groups to automorphism groups, Sylow's theorem and consequences, simplicity of alternating groups and conjugacy in Sn by presentation.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
4. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998
7. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.
8. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

SEMESTER – V		
Name of the Course: **Linear Programming**		
Course Code: **UGMATHDSE01**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%		

Course Outcomes (UGMATHDSE01)

The prime objectives of the course are:

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- To develop the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research.
- Understand the Linear programming problems with applications to transportation, assignment and game problem.
- Understand the application of linear programming problems in manufacturing resource planning and financial sectors.

Course Content

Linear Programming

Unit 1: Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. [30]

Unit 2: Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.

Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem. [30]

Unit 3: Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games. [30]

Question Pattern for End Semester Examination (Course Code: UGMATHDSE01)

Unit-1 (Linear Programming, 15 marks)

1. Attempt 3 questions out of 4 question and each question carries 5 marks = 3×5 =15

Unit-2 (Linear Programming, 20 marks)

2. Attempt 4 questions out of 6 questions and each question carries 5 marks = 4×5 =20

Unit-3 (Linear Programming, 15 marks)

3. Attempt 3 questions out of 4 questions and each question carries 5 marks = 3×5 =15

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Course Outcomes(UGMATHDSE01)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Formulate optimization problems and solve them using different methods.	C	PO4, PO6	PSO5
CO 2	Place a Primal linear programming problem into standard form and use the Simplex Method or Revised Simplex Method to solve it and find the dual, and identify and interpret the solution of the Dual Problem from the final tableau of the Primal problem.	E, C	PO4, PO6	PSO5
CO 3	Explains the Transportation Problem and Assignment Problem, formulate them as an LPP and hence solve the problem.	E, C	PO4, PO6	PSO5
CO 4	To understand the theory of games for solving simple games.	U, C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C =creating

Recommended Books

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
4. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

SEMESTER – V	
Name of the Course: **Probability and Statistics**	
Course Code: **UGMATHDSE02**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 65
Tutorial	Credits: 1 Full Marks: 35
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%	

Course Objectives (UGMATHDSE02)

The prime objectives of the course are:

- To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.

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- To render the students to several examples and exercises that blend their everyday experiences with their scientific interests.
- To extend and formalize knowledge of the theory of probability and use of Baye's theorem.
- To inculcate the concepts of random variables, mathematical expectation and correlation.
- Fostering the concept of discrete and continuous probability distributions.

Course Content

Probability and Statistics

Unit1: Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. [25]

Unit2: Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf)and calculation of covariance (from jmgf), linear regression for two variables. [25]

Unit3: Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central limit theorem for independent and identically distributed random variables with finite variance, Markov chains, Chapman- Kolmogorov equations, classification of states. [25]

Unit4: Random Samples, Sampling Distributions, Estimation of parameters, Testing of hypothesis. [15]

Question Pattern for End Semester Examination (Course Code: UGMATHDSE02)

Unit-1 (Probability and Statistics, 12 marks)

1. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
2. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×5 =10

Unit-2 (Probability and Statistics, 12 marks)

3. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
4. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×5 =10

Unit-3 (Probability and Statistics, 14 marks)

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5. Attempt 2 questions out of 3 question and each question carries 2 marks = 2×2 =4
6. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×5 =10

Unit-4 (Probability and Statistics, 12 marks)

7. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
8. Attempt 2 questions out of 3 questions and each question carries 5 marks = 2×5 =10

Course Outcomes (UGMATHDSE02)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Compute probabilities and conditional probabilities in appropriate ways.	An	PO4, PO6	PSO4
CO 2	Represent and statistically analyse data both graphically and numerically.	An, E	PO4, PO6	PSO4
CO 3	Demonstrate the ability of conditional probabilities statistically analyse data both graphically and numerically by presentation.	E, C	PO4, PO6	PSO5
CO 4	Solve word problems using combinatorial analysis.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Irwin Miller an Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007
5. A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers.

SEMESTER – VI		
Name of the Course: **Metric Spaces and Complex Analysis**		
Course Code: **UGMATHCC13**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%		

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Course Objectives (UGMATHCC13)

The prime objectives of the course are:

- Understand the concepts of analysis which evidently rely on the notion of distance.
- To develop the usual idea of distance into an abstract form on any set of objects, maintaining its inherent characteristics, and the resulting consequences.
- To introduce the basic ideas of analysis for complex functions in complex variables with visualization through relevant practicals.
- Understand the Cauchy's theorems, series expansions and calculation of residues.

Course Content

Metric Spaces and Complex Analysis

Unit1: Metric spaces: sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's theorem. [10]

Unit2: Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Connectedness, connected subsets of R. Compactness: Sequential compactness, Heine-Borel property, totally bounded spaces, finite intersection property, and continuous functions on compact sets. Homeomorphism. Contraction mappings. Banach fixed point theorem and its application to ordinary differential equation. [20]

Unit3: Limits, limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings.
Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. [20]

Unit4: Analytic functions, examples of analytic functions, exponential function, logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula. [20]

Unit5: Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. [10]

Unit6: Laurent series and its examples, absolute and uniform convergence of power series. [10]

Question Pattern for End Semester Examination (Course Code: UGMATHCC13)

Unit-1 (Metric Spaces and Complex Analysis, 10 marks)

1. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-2 (Metric Spaces and Complex Analysis, 10 marks)

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3. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
4. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-3 (Metric Spaces and Complex Analysis, 10 marks)

5. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
6. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-4 (Metric Spaces and Complex Analysis, 8 marks)

7. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-5 (Metric Spaces and Complex Analysis, 6 marks)

8. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
9. Attempt 1 questions out of 2 questions and each question carries 4 marks = 1×4 =4

Unit-6 (Metric Spaces and Complex Analysis, 6 marks)

10. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
11. Attempt 1 questions out of 2 questions and each question carries 4 marks = 1×4 =4

Course Outcomes (UGMATHCC13)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	PSOs Addressed	PSOs Addressed
CO 1	Conceive the concepts of analytic functions and will be familiar with the elementary complex functions and their properties, and apply the concept and consequences of analyticity and the Cauchy Riemann equations and of results on harmonic and entire functions including the fundamental theorem of algebra.	R, U	PO1, PO2, PO3	PSO1
CO 2	Applies the theory into application of the power series expansion of analytic functions, and understand the basic methods of complex integration and its application in contour integration.	U, Ap	PO3, PO5	PSO2
CO 3	Demonstrate the knowledge of Cauchy sequences, Cantor's theorem, Heine-Borel property, contracting mapping, Homeomorphism and Banach fixed point theorem, through their application to ordinary differential equation.	U, Ap	PO3, PO5	PSO2
CO 4	Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.	E	PO3, PO4, PO5	PSO3
CO 5	Analyse weather a sequence in a metric space is convergent or not.	An	PO4, PO6	PSO4

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

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Recommended Books

1. Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
2. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.
6. S. Ponnusamy, Foundations of complex analysis.
7. E.M.Stein and R. Shakrachi, Complex Analysis, Princeton University Press

SEMESTER – VI		
Name of the Course: **Ring Theory and Linear Algebra II**		
Course Code: **UGMATHCC14**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%		

Course Objectives (UGMATHCC14)

The prime objectives of the study are:

- Introduce the basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers, used in finite fields with applications on cryptography.
- Emphasize the application of techniques using the adjoint of linear operator and their properties to least squares approximation and minimal solutions to systems of linear equations.
- Understand the unique factorization domain and its applications, Cayley Hamilton theorem and its consequences, orthogonal projections and spectral theorem.

Course Content

Ring Theory and Linear Algebra II

Unit 1: Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in Z[x]. Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclidean domains. [30]

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Unit 2: Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms. [30]

Unit 3: Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator. Least squares approximation, minimal solutions to systems of linear equations. Normal and self-adjoint operators. Orthogonal projections and Spectral theorem. [30]

Question Pattern for End Semester Examination (Course Code: UGMATHCC14)

Unit-1 (Ring Theory, 18 marks)

1. Attempt 3 questions out of 4 question and each question carries 2 marks = 3×2 =6
2. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-2 (Linear Algebra II, 18 marks)

3. Attempt 3 questions out of 4 question and each question carries 2 marks = 3×2 =6
4. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-3 (Linear Algebra II, 14 marks)

5. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
6. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Course Outcomes (UGMATHCC14)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	PSOs Addressed	PSOs Addressed
CO 1	Demonstrate knowledge of polynomial ring, integral domain, unique factorization domain and Euclidean domain.	U	PO1, PO2, PO3	PSO1
CO 2	Interpret the knowledge of dual space and basis, eigen space of linear operator and the minimal polynomial for a linear operator.	R, U	PO1, PO2, PO3	PSO1
CO 3	Develop the knowledge of inner product space, least squares approximation, normal and self-adjoint operator, spectral theorem.	Ap	PO3, PO5	PSO2
CO 4	Apply unique factorization domain and its applications, Cayley Hamilton theorem and its consequences, orthogonal projections and spectral theorem.	Ap	PO3, PO5	PSO2

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Recommended Books

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
4. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
7. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
8. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. S.H. Friedberg, A.L. Insel and L.E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd.2004

SEMESTER – VI	
Name of the Course: **Mechanics**	
Course Code: **UGMATHDSE03**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 65
Tutorial	Credits: 1 Full Marks: 35
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 20%	

Course Objectives (UGMATHDSE03)

The prime objectives of the course are:

- Understand the various concepts of physical quantities and the related effects on different bodies using mathematical techniques.
- Emphasize knowledge building for applying mathematics in physical world.
- To understand the concept of different forces and moments and their equilibrium with reference to a coordinate system.
- To widen appreciation of the variety of phenomena covered by mechanics and the techniques available to handle them.

Course Content

Mechanics

Unit 1: Co-planar forces. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work. Forces in three dimensions. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium. [30]

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Unit 2: Equations of motion referred to a set of rotating axes. Motion of a projectile in a resisting medium. Stability of nearly circular orbits. Motion under the inverse square law. Slightly disturbed orbits. Motion of artificial satellites. Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution. [30]

Unit 3: Degrees of freedom. Moments and products of inertia. Momental Ellipsoid. Principal axes. D'Alembert's Principle. Motion about a fixed axis. Compound pendulum. Motion of a rigid body in two dimensions under finite and impulsive forces. Conservation of momentum and energy. [30]

Question Pattern for End Semester Examination (Course Code: UGMATHDSE03)

Unit-1 (Mechanics, 20 marks)

1. Attempt 4 questions out of 6 questions and each question carries 5 marks = 4×5 =20

Unit-2 (Mechanics, 15 marks)

2. Attempt 3 questions out of 4 questions and each question carries 5 marks = 3×5 =15

Unit-3 (Mechanics, 15 marks)

3. Attempt 3 questions out of 4 questions and each question carries 5 marks = 3×5 =15

Course Outcomes (UGMATHDSE03)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Understand the virtual work, stable and unstable equilibrium.	R, U	PO1, PO2, PO3	PSO1
CO 2	Understand degree of freedom, D'Alembert's Principle, compound pendulum and conservation of momentum and energy.	U	PO1, PO2, PO3	PSO1
CO 3	Solve the problems on stability of nearly orbit, motion in a particle in 3D and motion on a smooth sphere, cone and any surface.	E	PO4, PO6	PSO4

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
3. Chorlton, F., Textbook of Dynamics.

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4. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.
5. Loney, S. L., Elements of Statics and Dynamics I and II.
6. Ghosh, M. C, Analytical Statics.
7. Verma, R. S., A Textbook on Statics, Pothishala, 1962.
8. Matiur Rahman, Md., Statics.
9. Ramsey, A. S., Dynamics (Part I).

SEMESTER – VI		
Name of the Course: **Bio Mathematics**		
Course Code: **UGMATHDSE04**		
Full Marks: 100		Credit: 6
Theory	Credits: 4 Full Marks: 65	
Practical	Credits: 2 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 30%		

Course Objectives (UGMATHDSE04)

The prime objectives of the course are:

- Understand the scientific study of normal functions in living systems.
- Exposure to nonlinear differential equations with examples such as heartbeat, chemical reactions and nerve impulse transmission.
- Understand the basic concepts of the probability to understand molecular evolution and genetics have also been applied.

Course Content

Bio Mathematics

Unit 1: Mathematical biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, bacterial growth in a chemostat, harvesting a single natural population, Prey predator systems and Lotka Volterra equations, populations in competitions, epidemic models (SI, SIR, SIRS, SIC) [20]

Unit 2: Activator-inhibitor system, insect outbreak model: Spruce Budworm. Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria. Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.
Spatial models: One species model with diffusion. Two species model with diffusion, conditions for diffusive instability, spreading colonies of microorganisms, Blood flow in circulatory system, travelling wave solutions, spread of genes in a population. [20]

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Unit 3: Discrete models: Overview of difference equations, steady state solution and linear stability analysis. Introduction to discrete models, linear models, growth models, decay models, drug delivery problem, discrete prey-predator models, density dependent growth models with harvesting, host-parasitoid systems (Nicholson-Bailey model), numerical solution of the models and its graphical representation. case studies. Optimal exploitation models, models in genetics, stage structure models, age structure models. [20]

Practical

- Graphical demonstration as Teaching aid using any software)
- Growth model (exponential case only).
- Decay model (exponential case only).
- Lake pollution model (with constant/seasonal flow and pollution concentration).
- Case of single cold pill and a course of cold pills.
- Limited growth of population (with and without harvesting).
- Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
- Epidemic model of infuenza (basic epidemic model, contagious for life, disease with carriers).
- Battle model (basic battle model, jungle warfare, long range weapons). [30]

Question Pattern for End Semester Examination (Course Code: UGMATHDSE03)

Unit-1 (Bio Mathematics, 20 marks)

1. Attempt 4 questions out of 6 questions and each question carries 5 marks = 4×5 =20

Unit-2 (Bio Mathematics, 15 marks)

2. Attempt 3 questions out of 4 questions and each question carries 5 marks = 3×5 =15

Unit-3 (Bio Mathematics, 15 marks)

3. Attempt 3 questions out of 4 questions and each question carries 5 marks = 3×5 =15

Course outcomes (UGMATHDSE04)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Demonstrate knowledge of SI, SIR, SIRS and SIC.	U	PO1, PO2, PO3	PSO1
CO 2	Illustrate knowledge about different types of models and applications.	U, Ap	PO3, PO4, PO5	PSO3
CO 3	Demonstrate the knowledge of Growth model, decay model, lake pollution model limited growth of population and battle model by practical.	Ap, E	PO3, PO4, PO5	PSO3

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Recommended Books

1. K. E. Watt: Ecology and Resource Management-A Quantitative Approach.
2. R. M. May: Stability and Complexity in Model Ecosystem.
3. Y. M. Svirezhev and D. O. Logofet : Stability of Biological Communities.
4. i. Segel : Modelling Dynamic Phenomena in Molecular Biology.
5. J. D. Murray: Mathematical Biology. Springer and Verlag.
6. N. T. J. Bailey: The Mathematical Approach to Biology and Medicine.
7. L. Perko (1991): Differential Equations and Dynamical Systems, Springer Verlag.
8. F. Verhulust (1996): Nonlinear Differential Equations and Dynamical Systems, Springer Verlag.
9. H. I. Freedman - Deterministic Mathematical Models in Population Ecology.
10. Mark Kot (2001): Elements of Mathematical Ecology, Cambridge Univ. Press

SEMESTER – VI		
Name of the Course: **Point Set Topology**		
Course Code: **UGMATHDSE04**		
Full Marks: 100		Credit: 6
Theory	Credits: 5 Full Marks: 65	
Tutorial	Credits: 1 Full Marks: 35	
Number of classes required: 90		
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%		

Course Objectives (UGMATHDSE04)

The prime objectives of the course are:

- Understand the concept of countable and uncountable sets, and some related basic theorems.
- Introduce the students to topological spaces, basis and sub-basis, connected and path connected spaces.
- Understand the compact spaces, compact sets in R, compactness in metric spaces.

Course Content

Point Set Topology

Unit1: Countable and Uncountable Sets, Schroeder-Bernstein Theorem, Cantor's Theorem. Cardinal numbers and cardinal arithmetic. Continuum Hypothesis, Zorns Lemma, Axiom of Choice. Well-ordered sets, Hausdorff's maximal principle. Ordinal numbers. [30]

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Unit 2: Topological spaces, basis and Subbasis for a topology, subspace topology, interior points, limit points, derived set, boundary of a set, closed sets, closure and interior of a set. Continuous functions, open maps, closed maps and homeomorphisms. Product topology, quotient topology, metric topology, Baire category theorem. [30]

Unit 3: Connected and path connected spaces, connected sets in R, components and path components, local connectedness. Compact spaces, compact sets in R. Compactness in metric spaces. Totally bounded spaces, Ascoli-Arzela theorem, the Lebesgue number lemma. Local compactness. [30]

Question Pattern for End Semester Examination (Course Code: UGMATHDSE04)

Unit-1 (Point Set Topology, 18 marks)

1. Attempt 3 questions out of 4 question and each question carries 2 marks = 3×2 =6
2. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-2 (Point Set Topology, 18 marks)

3. Attempt 3 questions out of 4 question and each question carries 2 marks = 3×2 =6
4. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-3 (Point Set Topology, 14 marks)

5. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
6. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Course Outcome (UGMATHDSE04)

After completion of the syllabus, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Define and illustrate the concept of countable set and uncountable set, cardinal numbers and cardinal arithmetic, Zorns lemma and ordinal numbers.	R, U	PO1, PO2, PO3	PSO1
CO 2	Demonstrate the concept of topological spaces and continuous functions, product topology and quotient topology, metric topology and Baire category theorem.	U	PO1, PO2, PO3	PSO1
CO 3	Define connectedness, compactness, and totally bounded spaces prove a selection of related theorems.	R, U	PO1, PO2, PO3	PSO1
CO 4	Students will demonstrate the ability of topological spaces and analyze some important theorem by presentation.	An	PO3, PO5	PSO2

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

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Recommended Books

1. Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. Dugundji, J., Topology, Allyn and Bacon, 1966.
3. Simmons, G.F., Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
4. Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York, 1995.
5. Hocking, J., Young, G., Topology, Addison-Wesley Reading, 1961.
6. Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart and Winston, New York, 1970.
7. Abhijit Dasgupta, Set Theory, Birkhäuser.

Generic Elective Subjects Syllabus	
Name of the Course: **Algebra**	
Course Code: **UGMATHGE01**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 50+35
Tutorial	Credits: 1 Full Marks: 15
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%	

Course Objectives (UGMATHGE01)

The prime objectives of the course are:

- To work with matrices and determine if a given square matrix is invertible.
- Learn to solve systems of linear equations and application problems requiring them.
- Compute determinants and know their properties.
- To find and use eigenvalues and eigenvectors of a matrix.
- Learn about and work with vector spaces and subspaces.

Course Content

Algebra

Unit1: Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications. Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, cubic and biquadratic equation.

Inequality: The inequality involving AM ≥ GM ≥ HM, Cauchy-Schwartz inequality. [20]

Unit2: Equivalence relations. Functions, composition of functions, Invertible functions, one to one correspondence and cardinality of a set. Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical induction, statement of Fundamental Theorem of Arithmetic. [20]

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Unit3: Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax = b, solution sets of linear systems, applications of linear systems, linear independence. [20]

Unit4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of Rn, dimension of subspaces of Rn, rank of a matrix, Eigen values, eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix. [20]

Unit5: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions. [10]

Question Pattern for End Semester Examination (Course Code: UGMATHGE01)

Unit-1 (Algebra, 10 marks)

1. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-2 (Algebra, 10 marks)

3. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
4. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-3 (Algebra, 10 marks)

5. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
6. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-4 (Algebra, 10 marks)

7. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
8. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-5 (Algebra, 10 marks)

9. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
10. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Course Outcomes (UGMATHGE01)

After completion of the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Define algebraic structures	R, U	PO1, PO2, PO3	PSO1
CO 2	Classify substructures.	U	PO1, PO2, PO3	PSO1
CO 3	Analyze a given structure in detail.	An	PO3, PO5	PSO2

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CO 4	Compare structures.	E	PO4, PO6	PSO4
CO 5	Develop new structures based on given structures.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., 3. 3. Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
4. K.B. Dutta, Matrix and linear algebra.
5. K. Hoffman, R. Kunze, Linear algebra.
6. W.S. Burnstine and A.W. Panton, Theory of equations.

Generic Elective Subjects Syllabus	
Name of the Course: **Calculus, Geometry and Differential Equations**	
Course Code: **UGMATHGE02**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 50+35
Tutorial	Credits: 1 Full Marks: 15
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%	

Course Objectives (UGMATHGE02)

The prime objectives of the course are:

- To introduce the basic tools of calculus and geometric properties of different conic sections which are helpful in understanding their applications in planetary motion, design of telescope and to the real-world problems.
- To carry out the hand on sessions in computer lab to have a deep conceptual understanding of the above tools to widen the horizon of students' self-experience.
- To introduce the students to the exciting world of differential equations, mathematical modelling and their applications.

Course Content

Calculus, Geometry and Differential Equations

Unit1: Higher order derivatives, Leibnitz rule and its applications to problems, L'Hospital's rule and its applications. concavity and inflection points, envelopes, asymptotes, curve tracing in cartesian coordinates, tracing in polar coordinates of standard curves. [15]

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Unit2: Reduction formulae, derivations and illustrations of reduction formulae of the type ∫sinnxdx, ∫cosnxdx, ∫tannxdx, ∫secnxdx, ∫(log x)n dx, ∫sinnxcosmx dx. Parametric equations, parameterizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution, techniques of sketching conics. [15]

Unit3: Reflection properties of conics, rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics. Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, generating lines, classification of quadrics, illustrations of graphing standard quadric surfaces like cone, ellipsoid. [25]

Unit4: Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters. [25]

Unit5: Definition of vector field, divergence and curl. Line integrals, applications of line integrals: mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path [10]

Question Pattern for End Semester Examination (Course Code: UGMATHGE02)

Unit-1 (Calculus, Geometry and Differential Equations, 10 marks)

1. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-2 (Calculus, Geometry and Differential Equations, 8 marks)

3. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-3 (Calculus, Geometry and Differential Equations, 14 marks)

4. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
5. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-4 (Calculus, Geometry and Differential Equations, 10 marks)

6. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
7. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-5 (Calculus, Geometry and Differential Equations, 8 marks)

8. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Course Outcomes (UGMATHGE02)

After the completion of the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Define vector field, divergence and curl and solve related problems.	R, U	PO1, PO2, PO3	PSO1
CO 2	Solve first order differential equations utilizing the standard techniques for separable, exact, linear, homogeneous, or Bernoulli cases.	Ap	PO3, PO5	PSO2
CO 3	Solve linear differential equations of both first and second order and apply differential equation techniques to predict the behaviour of certain phenomena.	Ap, An	PO4, PO6	PSO4
CO 4	Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.	Ap, An	PO4, PO6	PSO4
CO 5	Extract information from differential models in order to interpret reality and identify real phenomena as models of differential equations.	C	PO4, PO6	PSO5

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
5. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
6. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
7. G.F. Simmons, Differential Equations, Tata Mcgraw Hill.
8. T. Apostol, Calculus, Volumes I and II.
9. S. Goldberg, Calculus and mathematical analysis.

Generic Elective Subjects Syllabus	
Name of the Course: **Numerical Methods**	
Course Code: **UGMATHGE03**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 50+35
Tutorial	Credits: 1 Full Marks: 15
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 30%	

Course Objectives (UGMATHGE03)

The prime objectives of the course are:

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

Course Content

Numerical Methods

Unit1: Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation [5]

Unit2: Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods. [15]

Unit3: System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition [10]

Unit4: Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Numerical differentiation: Methods based on interpolations, methods based on [18]

Unit5: Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. midpoint rule, Composite trapezoidal rule, composite Simpson's 1/3rd rule, Gauss quadrature formula.
The algebraic eigen value problem. Power method. Approximation. Least square polynomial approximation [27]

Unit6: Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four. [15]

Question Pattern for End Semester Examination (Course Code: UGMATHGE03)

Unit-1 (Numerical Methods, 10 marks)

1. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-2 (Numerical Methods, 8 marks)

3. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-3 (Numerical Methods, 14 marks)

4. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
5. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-4 (Numerical Methods, 10 marks)

6. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
7. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-5 (Numerical Methods, 8 marks)

8. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Course Outcomes (UGMATHGE03)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	PSOs Addressed	PSOs Addressed
CO 1	Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.	R, U	PO1, PO2, PO3	PSO1
CO 2	Analyse and evaluate the accuracy of common numerical methods.	An, E	PO3, PO4, PO5	PSO3

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering
3. Computation, 6th Ed., New age International Publisher, India, 2007.

4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co.
8. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
9. Yashavant Kanetkar, Let Us C , BPB Publications

Generic Elective Subjects Syllabus	
Name of the Course: **Group Theory**	
Course Code: **UGMATHGE04**	
Full Marks: 100	Credit: 6
Theory	Credits: 5 Full Marks: 50+35
Tutorial	Credits: 1 Full Marks: 15
Number of classes required: 90	
Percentage of syllabus added or replaced vide BOS resolution dated 16.08.2019: 25%	

Course Objectives (UGMATHGE04)

The prime objectives of the course are:

- To introduce the fundamental theory of groups and their homomorphisms.
- Understand symmetric groups and group of symmetries in detail.
- Understand Fermat's Little theorem as a consequence of the Lagrange's theorem on finite groups.
- Understand the abstract algebra with applications to practical real-world problems.

Course Content

Group Theory

Unit1: Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups. [15]

Unit2: Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. [15]

Unit3: Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

[20]

Unit4: External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups. [20]

Unit5: Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems. [20]

Question Pattern for End Semester Examination (Course Code: UGMATHGE04)

Unit-1 (Group Theory, 10 marks)

1. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
2. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-2 (Group Theory, 8 marks)

3. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-3 (Group Theory, 14 marks)

4. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
5. Attempt 3 questions out of 4 questions and each question carries 4 marks = 3×4 =12

Unit-4 (Group Theory, 10 marks)

6. Attempt 1 questions out of 2 question and each question carries 2 marks = 1×2 =2
7. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Unit-5 (Group Theory, 8 marks)

8. Attempt 2 questions out of 3 questions and each question carries 4 marks = 2×4 =8

Course Outcomes (UGMATHGE04)

After completing the course, students will be able to

CO. No.	Course Outcome	Cognitive Level	POs Addressed	PSOs Addressed
CO 1	Extend group structure to finite permutation groups (Caley Hamilton Theorem).	R, U	PO1, PO2, PO3	PSO1
CO 2	Generate groups given specific conditions.	E	PO3, PO4, PO5	PSO3
CO 3	Generate symmetry using group theory.	E	PO3, PO4, PO5	PSO3
CO 4	Analyse algebra of electrical circuits, and the algebra of logic.	An, C	PO4, PO6	PSO4

R= remembering, U = understanding, Ap = applying, An = analysing, E = evaluating, and C = creating

Recommended Books

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
6. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.