

SYLLABUS
for
Choice Based Credit System
(CBCS)

On the basis of
Outcome Based Education
(OBE)

MATHEMATICS HONOURS

PATNA WOMEN'S COLLEGE

Autonomous

PATNA UNIVERSITY

3rd Cycle NAAC Accredited at 'A' Grade with CGPA 3.58/4
"College with Potential for Excellence" (CPE) Status Accorded by UGC

Vision

Rooted in the life, vision, and teachings of Jesus Christ and inspired by Mother Veronica, the foundress of the Apostolic Carmel, Patna Women's College strives to become a centre of academic excellence in higher education, social responsibility, and empowerment of women.

Mission Statement

Patna Women's College, the first college for women in Bihar, is committed to the holistic development of women so as to make an effective contribution to the creation of a better society.

To this end, we strive

- To become a center of excellence in higher education for women in an atmosphere of autonomy.
- To excel in teaching-learning, research, and consultancy.
- To provide education that promotes capacity building and holistic development of a person.
- To offer subjects for competency building and motivate/animate a workforce imbued with human values.
- To promote patriotism, communal harmony and cultural integration to maintain a free and peaceful atmosphere on the campus.
- To train the students in creative arts, social service, critical thinking, and leadership in order to make an effective contribution to the creation of a new and value-based society.
- To create women leaders and to make them agents of social change.
- To develop skill oriented and value-based courses, for the all-round development of individuals.
- To promote academic exchange and academia-industry interface.
- To form young women who are 'always wise' and who will dare to 'go ahead and conquer knowledge' through, competence, commitment, delicate conscience, and compassion.

Program: B.Sc. Mathematics

PROGRAM OUTCOMES

Upon completion of the programme, the students will attain the ability to:

- PO1:** Inculcates in depth knowledge of Algebra, Calculus, Geometry, Analysis, Differential equations with practical and several other branches of Mathematics.
- PO2:** Grasp the basic ideas about the topics mentioned.
- PO3:** Get well acquainted with the different real-life applications arising in areas of Physics, Chemistry, engineering and many more using Mathematical Equations.
- PO4:** Understand an overall concept of algebraic structures through group theory and real analysis.
- PO5:** Gain skills to undertake further studies related to Mathematics.

PROGRAM SPECIFIC OUTCOMES

Upon completion of the programme, the students will attain the ability to:

- PSO1:** Develop basic concepts of the topic taught, which will help them in solving problems related to the topic and uplift their analytical abilities require to pursue higher studies of their choice so that they can achieve higher academic excellence.
- PSO2:** Apply the concepts to various fields such as Bio-Mathematics, Environmental science, Mathematical Finance, Mathematical Economics, Actuarial Science, Industrial Mathematics, Medical Sciences etc.
- PSO3:** Apply well equipped at different competitive examinations like IIT-JAM, NBHM, MTTS training programs etc. for higher studies in Mathematics. They also become eligible for public service examinations and other employment related examinations.
- PSO4:** Develop skills in problem solving, critical thinking and analytical reasoning.
- PSO5:** Develop logical capacity to great extent which will lay down a firm foundation of the fundamental concept.
- PSO6:** Gain advanced knowledge on topics in pure and applied Mathematics empowering the students to pursue higher degrees at reputed academic Institutions

B.Sc. (Honours) Mathematics

Note: 1 credit = 15 hours

1. Theory paper: 6 credits each (5Theory and 1 Tutorial).
2. Tutorial group of each theory paper should have a group size of 8 students.
3. Practical paper: 6 credits each (4Theory and 2 Practical).
4. Practical paper will not have tutorials.

Core Courses (6 credits each)

Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

Semester I

1. Calculus (P)
2. Algebra

Semester II

3. Real Analysis
4. Differential Equations (P)

Semester III

5. Theory of Real Functions
6. Group Theory I
7. PDE and Systems of ODE (P)

Semester IV

8. Numerical Methods (P)
9. Riemann Integration and Series of Functions
10. Ring Theory and Linear Algebra I

Semester V

11. Multivariate Calculus

12. Group Theory II

Semester VI

13. Metric Spaces and Complex Analysis
14. Ring Theory and Linear Algebra II

Generic Elective Papers (GE) (6 credits each)

Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/ subject and vice versa and such electives may also be referred to as Generic Elective.

Semester I

1. Calculus, Set theory, Algebra and Geometry

Semester II

2. Analysis, Programming, Differential Equations and Statics

Semester III

3. Partial Differential Equation, Fourier series, Graph Theory and Number Theory

Semester IV

- 4 Fuzzy Sets, Dynamics, Theory of Equations and Linear Algebra

Discipline Specific Elective (DSE) (6 credits each)

Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

Semester V

DSE-1

1. Number Theory/Analytical Geometry.

DSE-2

2. Probability and Statistics / Industrial Mathematics

Semester VI

DSE-3

3. Linear Programming / Theory of Equations

DSE-4

4. Differential Geometry / Mechanics

Skill Enhancement Course (SEC)(2Credits)

Skill Enhancement Courses (SEC): These courses may be chosen from a pool of courses designed to provide **value-based and/or skill-based knowledge**.

Semester III

1. Inter Religious Studies (Value based)

Semester IV

2. Logic and Sets (Skill based)

Mathematics (Hons.) CBCS Syllabus

Sem	Core Course (14) <u>6 Credits each</u>	Ability Enhancement Compulsory Course AECC (2) <u>2 Credits each</u>	Skill Enhancement Course SEC (2) <u>2 Credits each</u>	Discipline Specific Elective DSE (4) <u>6 Credits each</u>	Generic Elective GE (4) <u>6 Credits each</u>
I	MATH CC101: Calculus(P)	English/ MIL Communication/ Environmental Science			MATH GE101: Calculus, Set theory, Algebra and Geometry
	MATH CC102: Algebra				
II	MATH CC203: Real Analysis	English/ MIL Communication/ Environmental Science			MATH GE202: Analysis, Programmi ng, Differential Equations and Statics
	MATH CC204: Differential Equations(P)				
III	MATH CC305: Theory of Real Functions		IRS SEC301: Inter-Religious Studies (Value based)		MATH GE303: Partial Differential Equation, Fourier series , Graph Theory and Number Theory.
	MATH CC306: Group Theory I				
	MATH CC307: PDE and Systems of ODE (P)				
IV	MATH CC408: Numerical Methods (P)		MATH SEC402: Logic and sets (Skill based)		MATH GE404:

	MATH CC409: Riemann Integration and Series of Functions				Fuzzy Sets, Dynamics, Theory of Equations and Linear Algebra
	MATH CC410: Ring Theory and Linear Algebra I				
V	MATH CC511: Multivariate Calculus			MATH DSE501: Number Theory/Analytical Geometry	
	MATH CC512: Group Theory II			MATH DSE502: Probability and Statistics/Industrial Mathematics	
VI	MATH CC613: Metric Spaces and Complex Analysis			MATH DSE603: Linear Programming./ Theory of Equations	
	MATH CC614: Ring Theory and Linear Algebra II			MATH DSE604: Differential Geometry/Mechanics	

Course Structure for B.Sc. Mathematics (Hons.)

<u>Semester –I</u>	<u>Semester –II</u>
MATH CC101: Calculus(P)	MATH CC203: Real Analysis
MATH CC102: Algebra	MATH CC204: Differential Equations(P)
ENG AEC101 : English Communication HIN AEC101 : fgUnh O;kdj.k vkSj IEizs"k.k	EVS AEC202 : Environmental Science
MATH GE101: Calculus, Set theory, Algebra and Geometry	MATH GE202: Analysis, Programming, Differential Equations and Statics

<u>Semester –III</u>	<u>Semester –IV</u>
MATH CC305: Theory of Real Functions	MATH CC408: Numerical Methods (P)
MATH CC306: Group Theory I	MATH CC409: Riemann Integration and Series of Functions
MATH CC307: PDE and Systems of ODE (P)	MATH CC410: Ring Theory and Linear Algebra I
IRS SEC301 : Inter-Religious Studies (Value Based)	MATH SEC402: Logic and Sets
MATH GE303: Partial Differential Equation, Fourier Series, Graph Theory and Number Theory.	MATH GE404: Fuzzy Sets, Dynamics, Theory of Equations and Linear Algebra
<u>Semester –V</u>	<u>Semester –VI</u>
MATH CC511: Multivariate Calculus	MATH CC613: Metric Spaces and Complex Analysis
MATH CC512: Group Theory II	MATH CC614: Ring Theory and Linear Algebra II
MATH DSE501: Number Theory/ Analytical Geometry	MATH DSE603 : Linear Programming / Theory of Equations
MATH DSE502: Probability and Statistics/Industrial Mathematics	MATH DSE604: Differential Geometry / Mechanics

Details of Credits for Courses under B.Sc Honours

Mathematics

Semester	Course	Theory	Practical	Tutorial	Total Credits
<u>I. Core Course (14 Papers) – 06 credits each</u>					
I	1. Calculus(P)	4	2	-	6
	2. Algebra	5		1	6
II	3. Real Analysis	5	-	1	6
	4. Differential Equations(P)	4	2	-	6
III	5. Theory of Real Functions	5	-	1	6
	6. Group Theory I	5	-	1	6
	7. PDE and Systems of ODE (P)	4	2	-	6
IV	8. Numerical Methods (P)	4	2	-	6
	9. Riemann Integration and Series of Functions	5	-	1	6
	10. Ring Theory and Linear Algebra I	5	-	1	6
V	11. Multivariate Calculus	5	-	1	6
	12. Group Theory II	5	-	1	6
VI	13. Metric Spaces and Complex Analysis	5	-	1	6
	14. Ring Theory and Linear Algebra II	5	-	1	6
<u>II. Elective Course – 06 credits each</u>					
A. 1. Discipline Specific Elective- DSE(4 papers)					
V	1. Number Theory/ Analytical Geometry.	5	-	1	6
	2. Probability and Statistics / Industrial Mathematics	5	-	1	6
VI	3. Linear Programming / Theory of Equations	5	-	1	6
	4. Differential Geometry / Mechanics	5	-	1	6
B. 1. Generic Elective / Interdisciplinary (4 papers)					

I	1. Calculus, Set theory, Algebra and Geometry	5	-	1	6
II	2. Analysis, Programming, Differential Equations and statics.	5	-	1	6
III	3. Partial Differential Equation, Fourier series, Graph Theory and Number Theory	5	-	1	6
IV	4. Fuzzy Sets, Dynamics, Theory of Equations and Linear Algebra	5	-	1	6
III. Ability Enhancement Courses – 02 credits each					
1. Ability Enhancement Compulsory (AECC)					
I	English / Hindi Communication	2			2
II	Environmental Science	2			2
II. Skill Enhancement Course (SEC)					
III	1. Inter Religious Studies	2	-	-	2
IV	2. Logic and Sets	2		-	2
TOTAL					140

Institute should evolve a system/policy about ECA / General Interest / Hobby / Sports / NCC / NSS / related courses on its own.

*wherever there is practical there will be no tutorial and vice-versa.

Mathematics (Honours) Details of CBCS Syllabus

Core Courses (6 credits each)

SEMESTER – I

Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

Course Outcomes:

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

- CO1:** Sketch the curves in Cartesian and polar coordinate system and understand the ideas of derivatives and their higher order.
- CO2:** Understand geometrical terminology for angles, triangles, quadrilaterals and circles.
- CO3:** Provide geometrical and physical explanation of the integral of a vector field over a curve.
- CO4:** Apply these topics to solve the problems in physics and mechanical engineering.

MATH CC101 : Calculus (Practical)		
PWC (Theory: 4 credits + Practical: 2 credits)		
Unit	Topics to be covered	No. of hours
1	Higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$. Expansion of functions, partial differentiation and Euler's theorem. Concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications	15

	in business, economics and life sciences.	
2.	Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x \, dx$, $\int \cos^n x \, dx$, $\int \tan^n x \, dx$ and $\int \sec^n x \, dx$, $\int \sin^m x \sin^n x \, dx$, $\int \sin^m x \cos^n x \, dx$ etc. Volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution	15
3.	Rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics. Sphere, cone, cylinder, standard equation of conicoids and generating lines.	15
4	Scalar triple product and vector triple product, product of four vectors, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, radial and transverse velocity and acceleration modeling ballistics and planetary motion, Kepler's second law.	15
	<p>Practicals / Lab work to be performed on a computer</p> <p>List of Practical (using any software)</p> <p>Plotting of graphs of function $e^{ax + b}$, $\log(ax + b)$, $1/(ax + b)$, $\sin(ax + b)$, $\cos(ax + b)$, $ax + b$ and to illustrate the effect of a and b on the graph.</p> <p>Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.</p> <p>Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).</p> <p>Matrix operation (addition, multiplication, inverse, transpose).</p>	30

Reading List :

1. Thomas G. B. and Finney R. L. (2005). *Calculus*, 9th Ed., Pearson Education, Delhi.
2. Strauss M. J., Bradley G. L. and Smith K. J. (2007). *Calculus*, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. Anton H., Bivens I. and Davis S. (2002). *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore.
4. Courant R. and John F. (1989). *Introduction to Calculus and Analysis (Volumes I & II)*, Springer-Verlag, New York. Inc.
5. Khanna M.L. (2000). *Vector Algebra*, 22nd Ed., T.P.N. & Co., Meerut.
6. Vasishtha A.R. and Sharma S.K. (2005). *Integral Calculus*, 15th Ed., Krishna Prakashan Media (P) Ltd., Meerut.
7. Robert J.T Bell (2018). An elementary treatise on Coordinate geometry of three Dimension, 3rd Ed, Macmilan & Co ltd , Newyork.
8. Sharma J.N. and Sharma Bhudev. Three Dimensional Geometry.

SEMESTER – I

Course Outcomes:

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

CO1: Learn various set theoretic concepts, divisibility and Euclidean algorithm, principles of mathematical induction and fundamental theorem of arithmetic.

CO2: Learn various notions related to fuzzy sets and their recent applications.

CO3: Solve systems of linear equations and apply various concepts related to linear transformations and their applications to real world problems.

CO4: Gain knowledge about different trigonometric identities.

<u>MATH CC102</u> : Algebra		
PWC (Theory: 5 credits + Tutorial: 1 credit)		
Units	Topics to be covered	No. of hours
1	Polar representation of complex numbers, n^{th} roots of unity, Complex argument, De-Moivre's theorem for rational indices and its applications. Hyperbolic Functions, Summation of series, Gregory series.	10
2	Cartesian products of sets, Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Countable and uncountable sets, 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.	25
3	Fuzzy Sets and its types, Characteristics of fuzzy set, Equality, Containment, Union & Intersection of Fuzzy sets, Height Core, Support, Normal fuzzy set, Nucleus, Convex	10

	fuzzy sets and its algebra, product and difference.	
4	Solution of a systems of linear equations by matrix methods, row reduction and echelon forms, vector equations, the matrix equation $Ax=b$, solution sets of linear systems, applications of linear systems, linear independence. Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.	30
	Tutorial	15
	TOTAL	90

Reading List :

1. Andreescu T. and Andrica D. (2006). *Complex Numbers from A to Z*, Birkhauser
2. Goodaire E. G. and Parmenter M. M. (2005). *Discrete Mathematics with Graph Theory*, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint.
3. Lay D. C. (2007). *Linear Algebra and its Applications*, 3rd Ed., Pearson Education Asia, Indian Reprint.
4. Singh Surjeet (1997). *Linear Algebra*, 1st Ed., Vikas Publishing House Pvt. Ltd., Noida.
5. Singh Vinit K. (2015). *Introduction to Matrix Theory*, 1st Ed., Narosa Publishing House, New Delhi.
6. H. J. Zimmermann, Fuzzy Set theory and its Applications.
7. Pundir S.K (2015) Fuzzy Sets and their applications, 7th Ed , Pragati Prakashan, Meerut
8. Lalji Prasad, Higher Trigonometry by Paramount Publications.

SEMESTER – II

Course Outcomes:

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

CO1: Explain the basic ideas of real numbers and this set as a complete ordered field.

CO2: Acquire the basic knowledge of convergence and divergence of sequences and series.

CO3: Demonstrate an understanding of limits with their applications and rearrangement of series with their convergence.

CO4: Produce rigorous proofs of results that arise in the context of real analysis.

<u>MATH CC203</u> : Real Analysis		
PWC (Theory: 5 credits + Tutorial: 1 credit)		
Units	Topics to be covered	No. of hours
1	Review of Algebraic and Order Properties of R , δ -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, The Completeness Property of R , The Archimedean Property, Density of Rational (and Irrational) numbers in R , Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets. Fundamental theorem of Analysis.	20
2	Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for	20

	Sequences. Cauchy sequence, Cauchy's Convergence Criterion.	
3	Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's n^{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.	20
4	Rearrangement of terms, Pringsheim's Method, The Multiplication Theorem, Cauchy's Theorem, Abel's Theorem and Merten's Theorem.	15
	Tutorial	15
	TOTAL	90

Reading List :

1. Bartle R.G. and Sherbert D. R. (2002). *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
2. Bilodeau G.G., Thie P.R., Keough G.E. (2010). *An Introduction to Analysis*, 2nd Ed., Jones & Bartlett.
3. Thomson B.S., Bruckner A.M. and Bruckner J.B. (2001). *Elementary Real Analysis*, Prentice Hall.
4. Berberian S.K. (1994). *A First Course in Real Analysis*, Springer Verlag, New York.
5. Bali N.P. (2009). *Real Analysis*, 1st Ed., Firewall Media.
6. Malik S.C. and Arora Savita (2017). *Mathematical Analysis*, 5th Ed., New Age International (P) Limited, New Delhi.

SEMESTER – II

Course Outcomes:

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

CO1: Solve problems in Applied Mathematics using differential equations and learn drawing surfaces and meshgrid through MATLAB.

CO2: Solve real life situation problem and Identify research problem where differential equations can be used to model the system.

CO3: Develop the ideas how Applied Mathematics can be applied and generalised.

CO4: Solve linear second and higher order ordinary differential equations with constant coefficients using the methods of undetermined coefficients and variation of parameters, direct formulas .

<u>MATH CC204 : Differential Equations (Practical)</u>		
PWC (Theory : 4 credits + Practical: 2 credits)		
Unit	Topics to be covered	No. of hours
1	Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.	10
2	Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.	20
3	General solution of homogeneous equation of second order, principle of super position for homogeneous	25

	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.	
4	Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.	05
	<p>Practicals / Lab work to be performed on a computer</p> <ol style="list-style-type: none"> 1. Plotting of second order solution family of differential equation. 2. Plotting of third order solution family of differential equation. 3. Growth model (exponential case only). 4. Decay model (exponential case only). 5. Lake pollution model (with constant/seasonal flow and pollution concentration). 6. Case of single cold pill and a course of cold pills. 7. Limited growth of population (with and without harvesting). 8. Plotting of recursive sequences. 9. Study the convergence of sequences through plotting. 10. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. 11. Cauchy's root test by plotting n^{th} roots. 	30
	TOTAL	90

Reading List :

1. Barnes B. and Fulford G. R. (2009). *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab*, 2nd Ed., Taylor and Francis group, London and New York.
2. Edwards C.H. and Penny D.E. (2005). *Differential Equations and Boundary Value problems Computing and Modeling*, Pearson Education India.
3. Ross S.L. (2004). *Differential Equations*, 3rd Ed., John Wiley and Sons, India.
4. Abell M. L., Braselton J. P. (2004). *Differential Equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press.
5. Edward A. Bender. (2000). *An Introduction to Mathematical Modeling*, Dover Publications, Inc. Mineola, New York.

SEMESTER – III**Course Outcomes:**

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

CO1: Explain the notion of continuity and discontinuity in different contexts.

CO2: Acquire knowledge about the Uniform continuity and its difference with continuity.

CO3: Gain knowledge about expansions using Taylor's theorem.

CO4: Understand theorems associated with differentiability and their applications.

<u>MATH CC305</u> : Theory of Real Functions		
PWC (Theory: 5 credits + Tutorial: 1 credit)		
Units	Topics to be covered	No. of hours
1	Limits of functions ($\varepsilon-\delta$ 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	28

	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.	
2	Differentiability of a function at a point and in an interval, algebra of differentiable functions.	07
3	Rolle's theorem, Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities, Taylor's theorem to inequalities.	15
4	Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1 + x)$, $1/ax+b$ and $(1 + x)^n$.	25
	Tutorial	15
	TOTAL	90

Reading List :

1. Bartle R. and Sherbert D.R. (2003). *Introduction to Real Analysis*, John Wiley and Sons.
2. Ross K.A. (2004). *Elementary Analysis: The Theory of Calculus*, Springer.
3. Mattuck A. (1999). *Introduction to Analysis*, Prentice Hall.
4. Ghorpade S.R. and Limaye B.V. (2005). *A Course in Calculus and Real Analysis*, Springer.
5. Bali N.P. (2009). *Real Analysis*, 1st Ed., Fire Wall Media.
6. Malik S.C. and Arora Savita (2017). *Mathematical Analysis*, New Age International (P) Limited, New Delhi.

SEMESTER – III

Course Outcomes:

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

- CO1:** Recognize the mathematical objects that are groups and classify them as abelian, cyclic and permutation groups, etc.
- CO2:** Acquire knowledge related to the fundamental concepts of Groups and symmetrical figures and determine whether a given set and binary operation form a group.
- CO3:** Develop the study of homomorphisms and isomorphisms with applications.
- CO4:** State and prove the classification of finite abelian groups and the corresponding result for finitely generated abelian groups. Additionally, they will be able to prove some of the classic theorems of finite group theory including Cauchy's theorem.

MATH CC306 : Group Theory I		
PWC (Theory: 5 credits + Tutorial: 1 credit)		
Units	Topics to be covered	No. of hours
1	Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups.	10
2	Subgroups and examples of subgroups, normal subgroups, centralizer, normalizer, center of a group, product of two subgroups.	13
3	(a) 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 Theorem. (b) Group homomorphisms, properties of homomorphisms,	40

	Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.	
4	External direct product of a finite number of groups, factor groups, Cauchy's theorem for finite abelian groups.	12
	Tutorial	15
	TOTAL	90

Reading List :

1. Fraleigh J. B. (2002). *A First Course in Abstract Algebra*, 7th Ed., Pearson.
2. Artin A. (2011). *Abstract Algebra*, 2nd Ed., Pearson.
3. Gallian J.A. (1999). *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi.
4. Rotman J. J. (1995). *An Introduction to the Theory of Groups*, 4th Ed., Springer Verlag.
5. Herstein N. (1975). *Topics in Algebra*, Wiley Eastern Limited, India.

SEMESTER – III

Course Outcomes:

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

CO1: Use knowledge of partial differential equations, modeling, the general structure of solutions and analytic and numerical methods for solutions.

CO2: Develop skills in the formulation, solution, understanding and interpretation of PDE models.

CO3: Know about classifications of second order differential equations, concept of wave and heat equations with applications to real life situations.

CO4: Learn to solve cauchy's problem, wave equation ,heat equation through MATLAB Software and formulate physical problems as PDE using conservation laws.

MATH CC307 : PDE and Systems of ODE (Practical)		
PWC (Theory : 4 credits + Practical: 2 credits)		
Unit	Topics to be covered	No. of hours
1	Differential equations of the first order but not of the first degree. Singular solutions, Clairaut's form, Orthogonal Trajectories of family of curves, Total differential equation in three variables, Simultaneous differential equations.	15
2.	Formation of partial differential equations, Types of solutions, PDE's of the first order, Lagrange's solution, some special types of equation which can be solved easily by methods other than the general methods, Charpit's and Jacobi's general method of solution, Methods of separation of variables for solving first order partial differential equation, Cauchy problem for first order PDE.	15
3.	Partial differential equation of second and higher order, Homogeneous and non-homogeneous equation with constant coefficients, Partial differential equations reducible to equations with constant coefficients, Monge's Methods.	15
4	Classification of second order linear equations as hyperbolic, parabolic or elliptic, Reduction of second order linear equations to canonical forms, Concept of the wave equation and heat equation.	15
	<p>Practicals / Lab work to be performed on a computer</p> <p>List of Practicals (using any software)</p> <p>(i) Solution of Cauchy problem for first order PDE.</p> <p>(ii) Finding the characteristics for the first order PDE.</p> <p>(iii) Plot the integral surfaces of a given first order PDE with initial data.</p> <p>(iv) 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</p>	30

	$u(x,0) = \phi(x), u_t(x,0) = \psi(x), x \in R, t \geq 0$	
	TOTAL	90

Reading List :

1. Myint-U T. and Debnath L. (2006). *Linear Partial Differential Equations for Scientists and Engineers*, 4th edition, Springer, Indian reprint.
2. Ross S.L. (2004). *Differential equations*, 3rd Ed., John Wiley and Sons, India.
3. Abell M. L., Braselton J.P. (2004). *Differential equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press.
4. Raisinghania M.D. (2013). *Ordinary and Partial Differential Equations*, S.Chand Publishing House, Delhi.
5. Amaranath T. (2003). *An elementary course in Partial Differential Equations*, Narosa Publishing House, New Delhi.
6. Rao Sankara K. (2010). *Introduction to Partial Differential Equations*, 3rd Ed PHI Learning Pvt. Ltd.

SEMESTER – IV

Course Outcomes:

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

CO1: Understand algorithms, convergence and various types of errors.

CO2: Apply numerical methods for solving transcendental and algebraic equations and system of algebraic equations by using different methods.

CO3: Apply different types of interpolation methods and numerical methods for numerical integration.

CO4: Learn how to solve first order initial value problems of ordinary differential equations numerically using Euler's and Runge Kutta methods.

MATH CC408 : Numerical Methods (Practical)		
PWC (Theory : 4 credits + Practical: 2 credits)		
Unit	Topics to be covered	No. of hours
1	(a) Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. (b) Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.	18
2	System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.	12
3	(a) Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. (b) Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.	24
4	Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.	06
	Practicals / Lab work to be performed on a computer List of Practicals (using any software) (i) Calculate the sum $1/1 + 1/2 + 1/3 + 1/4 + \dots + 1/n$. (ii) To find the absolute value of an integer. (iii) Enter 100 integers into an array and sort them in an ascending order. (iv) Bisection Method. (v) Newton Raphson Method.	30

	(vi) LU decomposition Method. (vii) Lagrange Interpolation or Newton Interpolation. 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.	
	TOTAL	90

Reading List :

1. Bradie B. (2007). *A Friendly Introduction to Numerical Analysis*, Pearson Education, India.
2. Jain M.K., Iyengar S.R.K. and Jain R.K. (2007). *Numerical Methods for Scientific and Engineering Computation*, 6th Ed., New age International Publisher, India.
3. Gerald C.F. and Wheatley P.O.(2008). *Applied Numerical Analysis*, Pearson Education, India.
4. Ascher U. M. and Greif C. (2013). *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited.
5. Mathews J. H. and Fink K. D. (2012). *Numerical Methods using Matlab*, 4th Ed., PHI Learning Private Limited.
6. Gupta, Malik, Chauhan. (2013). *Calculus of Finite Differences & Numerical Analysis*. Revised Edition. Krishna Educational Publishers.

SEMESTER – IV

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

CO1: Acquire the idea about Riemann Integration and its applications to problems.

CO2: Develop skill in checking the Uniform Convergence of series using various tests.

CO3: Understand the notion of radius of Convergence in different contexts.

CO4: Understand Partitions and their refinements.

MATH CC409 : Riemann Integration and Series of Functions		
PWC (Theory: 5 credits + Tutorial: 1 credit)		
Units	Topics to be covered	No. of hours
1	Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions (limit and bound definition) 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 theorems of Calculus.	20
2	Improper integrals; Convergence of Beta and Gamma functions.	15
3	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
4	Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass	20

	Approximation Theorem.	
	Tutorial	15
	TOTAL	90

Reading List :

1. Ross K.A. (2004), *Elementary Analysis, The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
2. Bartle R.G. , Sherbert D.R. (2002). *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
3. Charles G. Denlinger (2011). *Elements of Real Analysis*, Jones & Bartlett (Student Edition).
4. Malik S.C. and Arora Savita (2017). *Mathematical Analysis*, New Age International (P) Limited, New Delhi.
5. Apostol Tom (1974). *Mathematical Analysis*, Addison-Wesley.

SEMESTER – IV

Course Outcomes:

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

- CO1:** Enhance their logical Capacity to a great extent.
- CO2:** Develop their analytical abilities in solving problems of Ring Theory.
- CO3:** Define Vector spaces, subspaces and some related concepts.
- CO4:** Learn linear transformations and its matrix representation including applications, isomorphism theorems and change of coordinate matrix.

MATH CC410 : Ring Theory and Linear Algebra I		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	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	20
2	Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients	15
3	Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces	20
4	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	20
	Tutorial	15
	TOTAL	90

Reading List :

1. Fraleigh John B. (2002). *A First Course in Abstract Algebra*, 7th Ed., Pearson.
2. Artin M. (2011). *Abstract Algebra*, 2nd Ed., Pearson.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence (2004). *Linear Algebra*, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi.
4. Gallian Joseph A. (1999). *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi.

5. Lang S. (2005). *Introduction to Linear Algebra*, 2nd Ed., Springer.
6. Strang Gilbert (2007). *Linear Algebra and its Applications*, Thomson.
7. Kumaresan S. (1999). *Linear Algebra- A Geometric Approach*, Prentice Hall of India.
8. Hoffman Kenneth, Kunze Ray Alden (1971). *Linear Algebra*, 2nd Ed., Prentice-Hall of India Pvt. Ltd.
9. Wallace D.A.R. (1998). *Groups, Rings and Fields*, Springer Verlag London Ltd.

SEMESTER – V

Course Outcomes:

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

CO1: Solve some problems arising in physics using mathematical equations.

CO2: Understand how calculus is applied to geometrical problems.

CO3: Develop the concepts needed for further study and research.

CO4: Develop the ability in the applicability of Mathematics to real life problems.

<u>MATH CC511</u> : Multivariate Calculus		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	Functions of several variables, limit and continuity of functions of two 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	30

	multipliers, Definition of vector field, divergence and curl	
2	Double integration over rectangular region, Double integrals in polar co-ordinates	10
3	Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates	10
4	Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals. Fundamental theorem for line integrals, conservative vector fields, independence of path, Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem	25
	Tutorial	15
	TOTAL	90

Reading List :

1. Thomas G.B. and Finney R.L. (2005). *Calculus*, 9th Ed., Pearson Education, Delhi.
2. Strauss M.J., Bradley G.L. and Smith K. J. (2007). *Calculus*, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
3. Marsden E., Tromba A.J. and Weinstein A. (2005). *Basic Multivariable Calculus*, Springer (SIE), Indian reprint.
4. Stewart James (2001). *Multivariable Calculus, Concepts and Contexts*, 2nd Ed., Brooks Cole, Thomson Learning, USA.
5. Malik S.C. and Arora Savita (2017). *Mathematical Analysis*, New Age International (P) Limited, New Delhi.

SEMESTER – V

Course Outcomes:

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

CO1: Describe automorphism of finite and infinite cyclic groups, applications of factor groups to automorphism groups, and characteristic subgroups.

CO2: Acquire knowledge about Internal and external direct products, fundamental theorem of finite abelian groups.

CO3: Learn Group actions, stabilizers, orbits, generalized Cayley's theorem, Index theorem and their applications.

CO4: Solve problems on Class equation, p -groups, Sylow's theorems with applications, Cauchy theorem, Simplicity and non-simplicity tests.

<u>MATH CC512</u> : Group Theory II		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	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.	20
2	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
3	Group actions, stabilizers and kernels, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley's theorem, Index theorem.	15
4	Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n , p -groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity	20

	of A_n for $n \geq 5$, non-simplicity tests	
	Tutorial	15
	TOTAL	90

Reading List :

1. Fraleigh John B. (2002). *A First Course in Abstract Algebra*, 7th Ed., Pearson.
2. Artin M. (2011). *Abstract Algebra*, 2nd Ed., Pearson.
3. Gallian Joseph A. (1999). *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House.
4. Dummit David S. and Foote Richard M. (2004). *Abstract Algebra*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
5. Durbin J.R. (2000). *Modern Algebra*, John Wiley & Sons, New York Inc.
6. Wallace D. A. R. (1998). *Groups, Rings and Fields*, Springer Verlag London Ltd.

SEMESTER – VI

Course Outcomes:

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

- CO1:** Develop analytical study of complex analysis along with problem solving techniques.
- CO2:** Develop concept of Metric spaces as it is an important part of pure mathematics.
- CO3:** Analyze problem related to the metric space and its generalization over different spaces.
- CO4:** Develop the ideas how pure mathematics can be applied and generalized.

MATH CC613 : Metric Spaces and Complex Analysis		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism.	30
2	Properties of complex numbers, Limits, continuity and differentiability of complex functions, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability	10
3	Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy integral formula	15
4	(a) Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples (b) Laurent series and its examples, absolute and uniform convergence of power series. Concepts of Poles, Zeroes and Residues of Analytic functions.	20
	Tutorial	15
	TOTAL	90

Reading List :

1. Shirali Satish and Harikishan L. Vasudeva (2006). *Metric Spaces*, Springer Verlag, London.
2. Kumaresan S. (2011). *Topology of Metric Spaces*, 2nd Ed., Narosa Publishing House.
3. Simmons G.F. (2004). *Introduction to Topology and Modern Analysis*, McGraw-Hill.
4. Brown James Ward and Churchill Ruel V. (2009). *Complex Variables and Applications*, 8th Ed., McGraw – Hill International Edition.
5. Joseph Bak and Newman Donald J. (1997). *Complex Analysis*, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork.
6. Arumugam S. (2011) *Complex Analysis Revised Edition*, SCITECH Publishing(INDIA) PVT. LTD

SEMESTER – VI

Course Outcomes:

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

- CO1:** Gain knowledge about the fundamental concepts in ring theory such as the concepts of ideals, quotient rings, integral domains, and fields.
- CO2:** Learn in detail about different kinds of rings like polynomial ring, unique factorization domain, Euclidean domain etc.
- CO3:** Understand and compute dual spaces, dual basis, transpose of a linear transformation and its matrix in the dual basis.
- CO4:** Deal with the inner product spaces, operators on them, implications and their existence, orthogonal complements, Bessel's inequality with applications.

MATH CC614 : Ring Theory and Linear Algebra II		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains,	25

	factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in $\mathbb{Z}[x]$. Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains	
2	Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators.	15
3	Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator	15
4	Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Normal and self-adjoint operators.	20
	Tutorial	15
	TOTAL	90

Reading List

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

9. Friedberg S.H., Insel A.L. and Spence L.E. (2004). *Linear Algebra*, Prentice Hall of India Pvt. Ltd.

Generic Elective Papers (GE) (6 credits each)

SEMESTER – I

Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/ subject and vice versa and such electives may also be referred to as Generic Elective.

Course Outcomes:

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

- CO1:** Gain knowledge about Successive differentiation, Leibniz's theorem and Euler's theorem on homogeneous functions with some of its mathematical applications.
- CO2:** Develop the skills to estimate the change in the value of a function when the independent variable undergoes a change.
- CO3:** Compute dot product and cross product and gain knowledge about the Fundamental Theorem of Line Integrals, Green's Theorem, Stoke's Theorem, or Divergence Theorem to evaluate integrals
- CO4:** Learn about two and three Dimensional geometry with applications and gain knowledge related to fundamental concepts of Set theory and Group theory.

MATH GE101 : Calculus, Set theory, Algebra and Geometry		
PWC (Theory – 5 credits +Tutorial -1credits)		
Units	Topics to be covered	No. of hours
1	Successive differentiation, Leibnitz theorem, Expansion of functions (in Taylor's and Maclaurin's series), Indeterminate forms, Partial differentiation and Euler's theorem, Reduction formula, Beta and Gamma functions, Double and triple integration, Change of order of integration.	25
2	De Morgan's law, Cartesian product, Equivalence relation, Partition of set Equivalence class, Fundamental theorem of equivalence relation, Functions and their compositions, Set functions, Definition and examples of Group, Abelian and Non-abelian group, Uniqueness of Identity element in a group, Cancellation laws for groups, Subgroup, Cyclic group, Ring, Integral domain, Field: their definitions, examples, and basic properties	15
3	System of circles, Orthogonal circles, Co-axial circles, Parabola, Ellipse and Hyperbola: their standard equations, Equations of tangent and normal, General equation of the second degree, Conditions for different type of conic sections. Direction cosine and direction ratios, Angle between two lines, Equation of plane in different forms, skew lines and shortest distance, Equation of sphere and tangent plane	25
4	Product of three and four vectors, Gradient, Divergence and Curl, <i>Theorems of Gauss, Green, and Stokes (applications only).</i>	10
	Tutorial	15
	Total	90

Reading List :

1. Gupta A. D., Prasad S. B. & A. B. B. Lal (1989). *Degree Level Analytical Geometry of Two Dimensions*, Bharti Bhawan Patna.
2. Gupta A. D. & Prasad S. B. (1991). *Degree Level Analytical Geometry of Three Dimensions*, Bharti Bhawan Patna.

3. Mishra S. K., Gupta A. D. & Prasad S. B. (1993). *Degree Level Differential Calculus*, Bharti Bhawan Patna.
4. Prasad Lalji (2010). *Degree Set Theory*, Paramount Publications Patna.
5. Prasad Lalji (2015). *Vector Analysis*, Paramount Publications Patna.
6. Narayan Shanti & Mittal P. K. (2007). *Integral Calculus*, S. Chand & Company Ltd., New Delhi.

SEMESTER – II

Course Outcomes:

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

CO1: Grasp an overall concept of Infinite series and its convergence.

CO2: Understand composition of a system of coplanar forces acting on a rigid body and establish the conditions for their equilibrium.

CO3: Comprehend the concept of works and virtual works done by forces acting on a particle or a body and able to solve the practical problems.

CO4: Solve linear programming problems, transportation problems, assignment problems, game theory problems and second order ordinary differential equations with constant coefficients.

MATH GE202 : Analysis, Linear Programming, Differential Equations and PWC Statics. (Theory - 5credits+ Tutorial -1credit)		
Units	Topics to be covered	No. of hours
1	Reduction of a system of coplanar forces, equations of line of action of resultant, Principle of virtual work.	15
2	Convex set and its properties, Graphical solution of LPP,	15

	Theory of simplex method (problems only), Transportation problems, Assignment problems and Game theory. Binary Numbers,	
3	Differential equations of first order and first degree, differential equation of first order and higher degree, Clairaut's form, Singular solutions, Orthogonal trajectories, Linear differential equations of the second order with constant coefficients.	20
4	Infinite series, Cauchy's general principle of convergence, convergent and divergent series, convergence of a series of positive terms, comparison test, Cauchy's root test, D'Alembert ratio test, Raabe's test, Logarithmic test, Alternating series and Leibnitz test, Absolute convergence of series, continuity and differentiability of real function of one variable.	25
	Tutorial	15
	Total	90

Reading List:

1. Rahman M.M. (2014). Statics, New Central Book Agency
2. Prasad Lalji (2012). *Linear Programming*, Paramount Publications Patna.
3. Prasad Lalji (2015). *Differential Equations*, Paramount Publications Patna.
4. Prasad Lalji(2015). Infinite Series, paramount Publications Patna.
5. Bali. N. P (2015) Real Analysis 6th Ed, Laxmi Publication Bangalore
6. Singh. Sen (2010) Degree Level Mechanics 2nd Ed Bharati Bhawan

SEMESTER – III

Course Outcomes:

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

CO1: Solve linear partial differential equations and partial differential equations of second order with constant coefficients.

CO2: Find Fourier series of odd and even functions, half range Fourier series and sum of series using Parseval's identity.

CO3: Understand and apply the basic concepts of Graph Theory including Eulerian trails, Bipartite and Planar graphs.

CO4: Know effectively about the theory of Numbers, primes, Diophantine equations etc.

MATH GE303 : Partial Differential Equation, Fourier series, Graph Theory and Number Theory PWC and Number Theory (Theory - 5credits + Tutorial -1credits)		
Units	Topics to be covered	No. of hours
1	Simultaneous differential equations, Formation of Partial Differential Equation, Lagrange's linear partial differential equations, partial differential equation of second order with constant coefficients.	20
2	Fourier Series for odd and even functions, Half range Fourier sine and cosine series, Parseval's identity.	15
3	Definition of Graphs, Paths, Circuits and Subgraph, induced subgraph, degree of a vertex, connectivity, Planar graphs and their properties , Tree and Simple application of graphs.	20
4	Divisibility theory in the integers, Division Algorithm, The Greatest common Divisor, The Euclidean Algorithm, The Diophantine Equations $ax+by=c$, Fundamental Theorem of	20

	Arithmetic.	
	Tutorial	15
	Total	90

Reading List:

1. Prasad Lalji (2015). *Differential Equations*, Paramount Publications Patna.
2. Grewal B. S. (2013). *Higher Engineering Mathematics*, 43rd Edition Khanna Publishers, New Delhi.
3. Deo Narsingh (2016) Graph theory with Application Engineering to computer science Dover Publication.
4. Burton David M. (2012) Elementary Number Theory 17th (Indian Edition) McGraw Hill Education (India) Private Limited. New Delhi.
5. Kishan Hari (2014) Number Theory 5th Edition Krishna Prakashan Media(P) Ltd.

SEMESTER – IV

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

CO1: Learn about various notions related to fuzzy sets.

CO2: Solve systems of homogeneous and non-homogeneous linear equations, problems of Eigen values, Eigen vectors and Cayley Hamilton theorem.

CO3: Solve higher order Algebraic equations through theory of equations.

CO4: Understand the dynamic changes in the body under the action of forces and gain knowledge about Projectiles.

MATH GE404 : Fuzzy Sets, Dynamics, Theory of Equations and Linear Algebra		
PWC (Theory-5credits + Tutorial -1credits)		
Units	Topics to be covered	No. of hours
1	Fuzzy Sets and its types, Characteristics of fuzzy set, Equality, Containment, Union and Intersection of Fuzzy sets, Height, Core, Support, Normal fuzzy set.	20
2	Rectilinear motion in non-resisting and resisting medium, Elastic String and spring, Hooke's law (related problems), Motion in two dimensions, Radial and Transverse velocity and acceleration.	20
3	Relation between roots and coefficients, Problems based on <i>Descartes' rule of signs</i> , Symmetric functions of the roots of the equations.	15
4	Rank of matrix, Echelon form, Consistency of system of linear equations(homogeneous and <i>non-homogeneous equations</i>), Eigen values and Eigen vectors, Cayley Hamilton theorem (problems only), Vector space, Subspace, Linear Independent and Linear dependent Vectors.	20
	Tutorial	15
	Total	90

Reading List:

1. Singh P. & Sen D. K. (1989). *Degree Level Mechanics*, Bharti Bhawan Patna.
2. Immermann H.J. Z. Fuzzy Sets theory and its Applications.
3. Pundir S. K (2015) Fuzzy Set Theory and its Applications.

4. Prasad Lalji (2015). *Linear Algebra*, Paramount Publications Patna.
5. Prasad Lalji (2013). *Theory of equations*, Paramount Publications Patna.
6. Lipschutz Seymour and Lipson Mare (2017). *Schaum's Outlines : Linear Algebra*, 3rd edition, McGraw Hill Education.

Ability Enhancement Compulsory Courses (AECC)

English (2 Credits)

“AECC” courses are the courses based upon the content that leads to Knowledge enhancement; i. English/Hindi communication, ii. Environmental Science

Semester – I

Course Outcomes:

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

CO1: Communicate effectively using the techniques in the area of spoken as well as written communication.

CO2: Hone their LSRW skills within their communication.

CO3: Design and answer job interview questions

CO4: Demonstrate the ability to craft professional messages that are clear yet courteous.

ENG AEC101 : English Communication		
PWC (Theory :2 credits)		
Units	Topics to be covered	No. of hours
1	<u>Communication</u> (a) Definition of Communication	5

	(b) Stages of Communication (c) Barriers of Communication (d) Verbal and Non-verbal Communication (e) Skills of Communication – Listening, Reading, Writing, Speaking	
2	<u>Listening Skill</u> (a) Meaning and Importance of Listening (b) Principles of Good listening	5
3	<u>Writing Skills</u> (a) Notice, Agenda, Minutes of the meeting (b) Report writing, Circulars (c) Writing Resume (d) Building vocabulary	15
4	<u>Speaking Skill</u> (a) Interview (b) Meeting (c) Situational Conversation	5
	TOTAL	30

Suggested Readings:

1. Scot, O.; Contemporary *Business Communication*. Biztantra, New Delhi.
2. Lesikar, R.V. & Flatley, M.E.; *Basic Business Communication Skills for Empowering the Internet Generation*, Tata McGraw Hill Publishing Company Ltd. New Delhi.
3. Ludlow, R. & Panton, F.; *The Essence of Effective Communications*, Prentice Hall Of India Pvt. Ltd., New Delhi.
4. R. C. Bhatia, *Business Communication*, Ane Books Pvt Ltd, New Delhi.

SEMESTER I

HINAECC101– हिंदी-व्याकरण और सम्प्रेषण

परिणाम - 1. विभिन्न प्रतियोगी परीक्षाओं के लिए तैयार करना।

2. सम्प्रेषण-क्षमता की वृद्धि करना।

3. कार्यालयी-पत्र लेखन की क्षमता विकसित करना।

4. हिंदी के व्याकरणिक एवं सैद्धांतिक स्वरूप की जानकारी हासिल करना ॥

HIN AEC101		
हिन्दी व्याकरण और सम्प्रेषण		
PWC (Theory: 2 credits)		
Unit	Topics to be covered	No. of hours
1	हिन्दी व्याकरण और रचना : संज्ञा, सर्वनाम, विशेषण, क्रिया, अव्यय, उपसर्ग, प्रत्यय, समास, सन्धि, पर्यायवाची शब्द, विलोम शब्द, अनेक शब्दों के लिए एक शब्द, मुहावरे एवं लोकोक्तियाँ, पल्लवन, संक्षेपण, शब्द शुद्धि, वाक्य शुद्धि, विविध प्रकार के पत्र-लेखन	15
2	सम्प्रेषण : भाषिक सम्प्रेषण : स्वरूप और सिद्धांत, सम्प्रेषण की अवधारणा और महत्व, सम्प्रेषण की प्रक्रिया, सम्प्रेषण के विभिन्न मॉडल, सम्प्रेषण की चुनौतियाँ	05
3	सम्प्रेषण के प्रकार : मौखिक और लिखित, वैयक्तिक और सामाजिक, व्यावसायिक, भ्रामक सम्प्रेषण, सम्प्रेषण बाधाएँ और रणनीति	05
4	सम्प्रेषण के माध्यम : एकालाप, संवाद, सामूहिक चर्चा, प्रभावी सम्प्रेषण	05
	Total :	30

SEMESTER-II

Course Outcomes:

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

CO1: Understand multidisciplinary nature of environmental studies.

CO2: Understand the concept and types of natural resources and environmental pollution.

CO3: Evaluate the anomalies created due to haphazard population growth and its impact on environment.

CO4: Understand about the organizations, conventions and legislations working on mitigation of environmental issues.

<u>EVS AEC 202 : Environmental Science (2 Credits)</u>		
PWC		
Unit	Topics to be covered	No. of hours
1	(a) Multidisciplinary Nature of Environmental Studies: Definition, Scope and Importance. (b) Concept of Ecosystem: - Components, Elementary Idea of Major Ecosystem:	07
2	(a) Natural Resources : Land, Water, Forest And Mineral Resources : Introduction; Earth's Resources and Man; Renewable and Non-Renewable Resources ; Natural Resources and Associated Problems ; Non-Renewable Resources ; Renewable Resources ; Non-Renewable Energy; Renewable Energy, Conservation of Natural Resources	10

	<p>(b) Biodiversity and its conservation: Hotspots and threats to Biodiversity : Biodiversity ; Definition ; Keystone Species ; Conservation of Biodiversity ; Methods For The Conservation of Wildlife ; Hot Spots ; Types of Biodiversity ; Genetic, Species and Ecosystem Diversity, Threats to Biodiversity ; Endangered And Endemic Species ; Conservation of Biodiversity: In Situ And Ex-Situ ; Wildlife Sanctuaries and National Parks of India ; The Need for An Integrated Protected Area System (IPAS) ;; Beej Bachao Andolan ; List of Biosphere Reserves in India ; Tiger Reserves in India.</p>	
3	<p>Environmental Pollution:</p> <p>(a) Causes, Effects, and Control Measures ; Types and sources of Pollution.</p> <p>(i) Air Pollution ; Sources of air pollution and its impact on human health.</p> <p>(ii) Water Pollution and contamination: Introduction, Types and sources; Classification of Water Pollutants. Impact on human health</p> <p>(iii) Soil Pollution : Introduction: Contaminants and Degradation; Impact on human health.</p> <p>(iv) Noise Pollution: Effects of Noise Pollution on Physical Health; Permitted Noise Levels; Noise-Control Techniques. Impact on human health.</p> <p>(b) Public Awareness about Greenhouse Effects; Acid Rain; Effects; Ozone Layer Depletion, Ganga Action Plan (GAP); Chipko Movement; Chernobyl disaster; Bhopal Gas Tragedy.</p> <p>(c) Environment and Human Health: Outcome of</p>	05

	Unhygienic Environmental Conditions	
4	<p>Human Population and Environment and Important Organizations:</p> <p>(a) Population Growth, Variation Among Nations : Global Population Growth ; Population Explosion – Family Welfare Program ; Urban Poverty and The Environment ; Environment and Human Health ; Environmental Health ; Examples of Linkages ; Definition of Health Impact Assessment (HIA) by WHO ; Climate and Health ; Infectious Diseases; Water borne and water related diseases, Mitigation Strategies to control adverse health impact, Role of Information Technology in Environment and Human Health.</p> <p>(b) Important Organizations : IUCN ; WWF ; BNHS ; PETA; Important Dates and Years; Some Important Environmental Conventions ; Atmospheric conventions ; Biodiversity conventions ; Land conventions ; Hazardous wastes ; Some important Acts and Notifications in India ; Environment Action Programme – India (EAP) ; Environment Protection Act ; Penalties ; Air (Prevention and Control of Pollution) Act 1981 ; Penalties ; Water (Prevention and control of Pollution) Act ; Penalties ; Wildlife Protection Act ; Penalties ; Forest Conservation Act ; Penalties ; Issues involved in enforcement of environmental legislation.</p>	08
	TOTAL	30

Reading List :

1. Chandna R. C., 2002: *Environmental Geography*, Kalyani Publications, Ludhiana.

2. UNEP, 2007: *Global Environment Outlook: GEO4: Environment for Development*, United Nations Environment Programme
3. Odum, E. P. et al, 2005: *Fundamentals of Ecology*, Ceneage Learning India.
4. Singh S., 1997: *Environmental Geography*, Prayag Pustak Bhawan. Allahabad.
5. Baskar Sushmita and Baskar R. 2007 : *Environmental studies for Undergraduate Courses*, Unicorn Books, Bangalore

Discipline Specific Elective (DSE) (6 credits each)

SEMESTER – V

Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

Course Outcomes:

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

CO1: Acquire the basic knowledge about theory of numbers.

CO2: Gain the knowledge of Number Theoretic Problems in practical situations.

CO3: Acquire knowledge about encryption and decryptions and their applications.

CO4: Gain knowledge about unsolved problems in the field of Number theory.

MATH DSE501 : Number Theory		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.	25
2	Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.	25
3	Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli.	15
4	Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem.	10
	Tutorial	15
	TOTAL	90

Reading List :

1. Burton David M. (2007). *Elementary Number Theory*, 6th Ed., Tata McGraw-Hill, Indian reprint.
2. Neville Robinns (2007). *Beginning Number Theory*, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi.
3. Dudley Underwood (2008). *Elementary Number Theory*, Second Edition, Dover Publication Inc.
4. Stillwell John (2010). *Elements of Number Theory*, Springer.

5. Niven Ivan (2008). *An Introduction to the Theory of Numbers*, Wiley.

SEMESTER – V

Course Outcomes:

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

CO1: Acquire knowledge about sketching Parabola, Ellipse and Hyperbola.

CO2: Gain knowledge about reflection properties of Parabola, ellipse and Hyperbola.

CO3: Gain knowledge about classifications of Quadratic equations.

CO4: Understand illustrations of graphing, spheres and cylindrical surfaces.

<u>MATH DSE501</u> : Analytic Geometry		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	Techniques for sketching Parabola, Ellipse and Hyperbola. Reflection properties of Parabola, Ellipse and Hyperbola. Classification of Quadratic equations representing Lines, Parabola, Ellipse and Hyperbola.	20
2	Reflection properties of Parabola, Ellipse and Hyperbola.	10
3	Classification of Quadratic equations representing Lines, Parabola, Ellipse and Hyperbola.	10
4	Spheres, Cylindrical surfaces. Illustrations of Graphing Standard Quadric surfaces like Cone, Ellipsoid.	35
	Tutorial	15
	TOTAL	90

Reading List :

1. Thomas G.B. and Finney R.L. (2005). *Calculus*, 9th Ed., Pearson Education, Delhi.
2. Anton H., Bivens I. and Davis S. (2002). *Calculus*, John Wiley and Sons (Asia) Pvt. Ltd.
3. Loney S.L. (1896). *The Elements of Coordinate Geometry*, McMillan and Company, London.
4. R.J.T. Bill (1994). *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd.
5. Izu Vaisman (1998). *Analytic Geometry*, World Scientific Pub. Co. Inc.

SEMESTER – V

Course Outcomes:

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

- CO1:** Gain knowledge of Statistics and its scope and importance in various areas such as Mathematics, Medical, Engineering, Economics, Commerce and Social Sciences etc.
- CO2:** Apply Knowledge of various types of data, their organisation and evaluation of summary measures such as measures of central tendency and dispersion etc.
- CO3:** Develop knowledge to conceptualize the probabilities of events including classical, empirical and axiomatic approach of probability. Simultaneously, they will learn the notion of conditional probability including the concept of Baye's Theorem.
- CO4:** Analysis the concept of discrete and continuous random variables, their probability distributions and to apply standard discrete and continuous probability distributions to different situations.

MATH DSE502 : Probability and Statistics		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	Types of data: Discrete and Continuous data Frequency and non- frequency data, Different types of scales, Primary data, Secondary data. Construction of tables, diagrammatic and graphical representation of grouped data, frequency and cumulative frequency distribution and their application, Histogram, frequency polygon, ogives stem and leaf charts, box plot.	15
2	Concept of central tendency and its measures, partial values, dispersion and relative dispersion, moments, sheppard's correction for moments (without derivation), skewness, kurtosis and their measures.	15
3	Random experiment, Trial, Sample space, definitions of equally likely, Mutually exclusive and exhaustive events, definition of probability, classical and relative frequency approach to probability, axiomatic approach to probability and its properties, total and compound Probability, Conditional probability theorem, Independent of events, Bayes Theorem and its applications.	20
4	Random variable: Concept of discrete random variable, probability mass function and distribution function, joint probability mass function of several random variables marginal and conditional probability mass function. Continuous random variable probability density function, joint density function of two continuous variables, marginal and conditional probability density functions.	25
	Tutorial	15
	TOTAL	90

Reading List :

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig (2007). *Introduction to Mathematical Statistics*, Pearson Education, Asia.
2. Irwin Miller and Marylees Miller, John E. Freund (2006). *Mathematical Statistics with Applications*, 7th Ed., Pearson Education, Asia.
3. Ross Sheldon (2007). *Introduction to Probability Models*, 9th Ed., Academic Press, Indian Reprint.
4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes (2007). *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw- Hill, Reprint.
5. Gupta S.C. and Kapoor V.K. (2014). *Fundamental of Mathematical Statistics*, Sultan Chand and Sons.

SEMESTER – V

Course Outcomes:

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

CO1: Analyze and solve medical imaging and inverse problems.

CO2: Employ Math and algebraic theories, concepts and skills to applications found in Machine tool technology.

CO3: Apply Fourier and inverse Fourier transforms to image reconstruction and CT scan.

CO4: Learn about various applications of Mathematics in X-ray, CT scan and Medical imaging.

<u>MATH DSE502</u> : Industrial Mathematics		
PWC (Theory :5 credits + Tutorial: 1 credit)		
Unit	Topics to be covered	No. of hours
1	Medical Imaging and Inverse Problems. The content X-ray and CT scan based on the knowledge of equations,	15

	complex numbers and matrices	
2	Introduction to Inverse problems: Why should we teach Inverse Problems? , Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography	15
3	(a) X-ray: Introduction, X-ray behavior and Beers Law (The fundament question of image construction) Lines in the place. (b) Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms). (c) Back Projection: Definition, properties and examples	20
4	CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan	25
	Tutorial	15
	TOTAL	90

Reading List :

1. Timothy G. Feeman (2010). *The Mathematics of Medical Imaging, A Beginners Guide*, Springer Under graduate Text in Mathematics and Technology, Springer.
2. Groetsch C.W. (1999). *Inverse Problems, Activities for Undergraduates*, The Mathematical Association of America.

3. Kirsch Andreas (2011). *An Introduction to the Mathematical Theory of Inverse Problems*, 2nd Ed., Springer.
4. Helgason Sigurdur (2013). *The Radon Transform*, Second Edition, Springer.
5. Freeman T.G. (2010). *The Mathematics of Medical Imaging*, Springer.
6. Dean S.R. (2007). *The Radon Transform and Some of its Applications*, Dover Publications Inc.

SEMESTER – VI

Course Outcomes:

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

CO1: Solve linear programming problems by using simplex, big M- and two-phase methods.

CO2: Form dual problem and establish primal-dual relationship.

CO3: Solve transportation problems by using north west, least cost and Vogel approximation methods and assignment problems by using Hungarian method.

CO4: Model the decision-making problems by using linear programming techniques.

<u>MATH DSE603</u> : Linear Programming		
PWC (Theory-5credits+Tutorial -1 credits)		
Unit	Topics to be covered	No. of hours
1	Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two phase method, Big-M method and their comparison.	20
2	Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	10

3	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
4	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.	15
	Tutorial	15
	TOTAL	90

Reading List:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali (2004). *Linear Programming and Network Flows*, 2nd Ed., John Wiley and Sons, India.
2. F.S. Hillier and G.J. Lieberman (2009). *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore.
3. Hamdy A. Taha (2006). *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India.
4. Hadley G. (2002). *Linear Programming*, Narosa Publishing House, New Delhi.
5. Prasad Lalji (2012). *Linear Programming*, Paramount Publications, Patna

SEMESTER – VI

Course Outcomes:

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

CO1: Solve various Polynomial equations, find relation between the roots and coefficient of equations.

CO2: Provide and explain general properties of equations and Polynomials.

CO3: Transform equations and solve reciprocal and binomial equations.

CO4: Apply Symmetric function of roots and Strum's theorem to different equations.

<u>MATH DSE603 : Theory of Equations</u>		
PWC (Theory-5credits+Tutorial -1credits)		
Units	Topics to be covered	No. of hours
1	General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.	20
2	Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.	20
3	Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.	15
4	Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic. Solution of numerical equations.	20

	Tutorial	15
	Total	90

Reading List:

1. Burnside W.S. and Panton A.W. (1954). *The Theory of Equations*, Dublin University Press.
2. MacDuffee C. C. (1954). *Theory of Equations*, John Wiley & Sons Inc.
3. Prasad Lalji (2012). *Theory of Equations*, Paramount Publications, Patna.
4. Khana M.L. (2002). *Theory of Equations*, J.P.N. & Co., Meerut.
5. Leonard Eugene Dickson (1914). *Elementary Theory of Equations*, J. Wiley & Sons.

SEMESTER – VI

Course Outcomes:

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

CO1: Understand the theory of surfaces and curves in three dimensions.

CO2: Acquire knowledge about method of the moving frame and overdetermined systems in Surface theory.

CO3: Provide examples of Manifolds and investigate their properties.

CO4: Understand the different concepts related to Tensors.

<u>MATH DSE604</u> : Differential Geometry		
PWC (Theory-5credits+Tutorial -1credits)		
Units	Topics to be covered	No. of hours
1	Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating	15

	circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.	
2	(a) Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines. (b) Developables: Developable associated with space curves and curves on surfaces, Minimal surfaces.	25
3	Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot's theorem.	15
4	Tensors: Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.	20
	Tutorial	15
	Total	90

Reading List :

1. Willmore T.J. (2012). *An Introduction to Differential Geometry*, Dover Publications.
2. O'Neill B. (2006). *Elementary Differential Geometry*, 2nd Ed., Academic Press.
3. Weatherburn C.E. (2003). *Differential Geometry of Three Dimensions*, Cambridge University Press.

4. Struik D.J. (1988). *Lectures on Classical Differential Geometry*, Dover Publications.
5. Lang S. (1999). *Fundamentals of Differential Geometry*, Springer.
6. Spain B. (2003). *Tensor Calculus: A Concise Course*, Dover Publications.

SEMESTER – VI

Course Outcomes:

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

CO1: Describe and articulate relative motion, inertial and non-inertial reference frames.

CO2: Apply laws of coulomb friction, Conservative force field to practical problems.

CO3: Introduce Analytical mechanics as a systematic tool for problem solving.

CO4: Apply the vector theorems, moment theorems of Mechanics and interpretation of their results.

MATH DSE604 : Mechanics		
PWC (Theory-5credits+Tutorial -1credits)		
Units	Topics to be covered	No. of hours
1	Moment of a force about a point and an axis, couple and couple moment, Moment of a couple about a line, resultant of a force system, distributed force system, free body diagram, free body involving interior sections, general equations of equilibrium, two point equivalent loading, problems arising from structures, static indeterminacy.	25
2	Laws of Coulomb friction, application to simple and complex surface contact friction problems, transmission of power through belts, screw jack, wedge, first moment of an area and the centroid, other centers, Theorem of Pappus-Guldinus.	12
3	Second moments and the product of area of a plane area, transfer theorems, relation between second moments and	13

	products of area, polar moment of area, principal axes.	
4	Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on center of mass, moment of momentum equation for a single particle and a system of particles, translation and rotation of rigid bodies, Chasles' theorem, general relationship between time derivatives of a vector for different references, relationship between velocities of a particle for different references, acceleration of particle for different references.	25
	Tutorial	15
	Total	90

Reading List :

1. Shames I.H. and Krishna Mohan Rao G. (2009). *Engineering Mechanics: Statics and Dynamics*, (4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
2. Hibbeler R.C. and Gupta Ashok, *Engineering Mechanics: Statics and Dynamics*, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
3. Bali N.P. (2012). *Goden Dynamics*, Laxmi Publications (P) Ltd., New Delhi.
4. Vasishtha A.R., Gupta R.K. and Vasishtha A.K. (2010). *Statistics*, 12th Ed., Krishna Prakashan Media (P) Ltd., Meerut.
5. Vasishtha A.R., Gupta R.K. and Vasishtha A.K. (2011). *Dynamics*, 15th Ed., Krishna Prakashan Media (P) Ltd., Meerut.

Skill Enhancement Course (SEC)(2Credits)

SEMESTER – III

Skill Enhancement Courses (SEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge.

Course Outcomes:

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

CO1: Develop Inter-religious harmony & better understanding of other religions.

CO2: Interpret the different religions of the world.

CO3: Identify the common elements that bind different religions together.

CO4: Acquaint with the salient features of different religions.

IRS SEC301 : Inter-Religious Studies (Value Based) (02credits)		
PWC		
Unit	Topics to be covered	No. of hours
1	Nature and Need of Inter-Religious study, Scope of Comparative Religion.	05
2	Salient Features of Hinduism, Jainism and Buddhism, Salient Features of Christianity, Islam and Sikhism.	10
3	Similarities and Differences among Religions, Conflicting Truth claims of different religions and inter-religious Harmony.	10
4	Religious Tolerance, Secularism.	05
	TOTAL	30

Reading List :

1. Chaudhary, C. Neeraj (1979). "Hinduism", B.I. Publication, New Delhi.
2. Devraj, N.K., (1917)-"Hinduism and Christianity" Asian Publishing House.
3. Gordh, George, -"Christian Faith and its Cultural Expression", Printed in USA.
4. Hick, John, - "Philosophy of Religion", Prentice Hall of India.

5. Hopfe, M.Lewis(1983)- "Religion of the World", Macmillan Publishing Co. Inc, New York
6. Masih,Y. (1990)- "Comparitive study of Relgion",Motilal Banarasidass.
7. Sethi,S. Arijit, Pummer, Reinhard, (1979)-"Comparitive Religion", Vikas Publishing House pvt. ltd, Delhi.
8. Singh, B.N.,(1994)-"Vishwa Dharma Darshan ki Samasyain", Ratna Printing Works.
9. Tiwari, Nath Kedar,(1983)-"Comparative Religion", Motilal Banarasidass.
10. Ward, CHS (1998) – 'Early Buddhism", Caxton Publication, Delhi.

SEMESTER – IV

Course Outcomes:

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

CO1: Understand foundations of mathematics and symbolic techniques in the context of problem solving.

CO2: Develop understanding of basic principles of sets, logic sets and operations in sets.

CO3: Apply formal methods of symbolic propositional and predicate logic and write an argument using logical notation.

CO4: Understand mathematical reasoning by understanding and exercising several proof techniques, such as direct proofs, proof by counterexample, proof by contraposition, proof by contradiction, mathematical induction, and strong induction.

MATH SEC402 : Logic and Sets		
PWC (Theory-2credits)		
Units	Topics to be covered	No. of hours
1	Introduction, propositions, truth table, negation, conjunction	10

	and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.	
2	Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set.	6
3	Standard set operations. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.	6
4	Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, Total Order Relation.	8
	Total	30

Reading List :

1. Grimaldi R.P. (1998). *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education.
2. Halmos P.R. (1974). *Naive Set Theory*, Springer.
3. Kamke E. (1950). *Theory of Sets*, Dover Publishers.
4. Robert R. Stoll (1979). *Set Theory and Logic*, Dover Publications Inc.
5. Nancy Rodgers (2000). *Learning to Reason : An Introduction to Logic*, Sets and Relations, Wiley-Interscience.