1.2.2

Supporting Documents-

Department of Mathematical Sciences

Copy of Syllabus of All Programs Offered Indicating Credits/Electives Approved by Board

1.1.2 & 1.2.2

Supporting Documents- Mathematical Sciences

Copy of syllabus of all programs offered indicating credits/electives approved by board

I.K. GUJRAL PUNJAB TECHNICAL UNIVERSITY

Estd. Under Punjab Technical University Act, 1996
(Punjab Act No. 1 of 1997)

Ref. No. : IKGPTU/Reg/N/ *Dated :*

NOTIFICATION

Sub: **Regarding Pre-Ph.D Course work.**

This is for information of all concerned that Pre-Ph.D course work from 2016-17 will be conducted in the IKGPTU main campus Kapurthala in regular mode. The PhD course work will consists of minimum 15 credits. The structure of the course work is as under.

Sr. No.	Nature of course	Name of course	Credits	Remarks
1.	Core	1.Research Methodology	4	The syllabus of RM should be formulated faculty wise such as Engineering, Science, Management/ Humanities and Life sciences
		2.Subject related theory paper	4	Discipline specific related to advancements in theoretical methods for research
		3. Presentation	3	Discipline specific
2.	Interdisciplinary	4. Elective	4	From list of subjects from allied fields
	Total Minimum credits		**15**	

-Sd-
Registrar

Endorsement No: IKGPTU/REG/N/ 4244-4251 Dated: 22.08.2016

1. Secretary to Vice Chancellor: For kind information of Vice Chancellor
2. Dean (P&D)
3. Dean (RIC)
4. Dean (Academics)
5. Finance Officer
6. Controller of Examination
7. DR (Computers): For uploading on website
8. File Copy

19/8/16
Registrar

I. K. Gujral Punjab Technical University, Jalandhar
Jalandhar Kapurthala Highway, Near Pushpa Gujral Science City, Kapurthala - 144 603
Ph. No. 01822 - 662521. 662501 Fax No. : 01822-255506. 662526. Email : registrar@ptu.ac.in

I.K. Gujral Punjab Technical University Jalandhar, Main Campus-Kapurthala

(Department of Mathematical Sciences)

Scheme of Pre-Ph.D. course work in Mathematics

Sr. No.	Subject with code	L	T	P	Credits	Remarks
1.	Research Methodology (MPHM-101)	4	-	-	4	Compulsory
2.	(i) Methods in Applied Mathematics (MPHM-102) (ii) Continuum Mechanics (MPHM-103) (iii) Advanced Analysis (MPHM-104) (iv) Advanced Number Theory (UC-MSM-504-18) (v) Advanced Numerical Methods (UC-MSM-510-18)	4	-	-	4	Any one
3.	Presentation (MPHM-105)	-	-	-	3	Discipline specific
4.	Interdisciplinary Subject	4	-	-	4	From list of subjects from allied fields
	Total minimum credits=15					

Note. The subject 'Methods in Applied Mathematics (MPHM-102)' has been offered as an interdisciplinary for other Departments.

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Mathematics

RESEARCH METHODOLOGY

MPHM-101

1. **Introduction to Research**Objectives of research, motivation in research, types of research, significance of research, research methods vs methodology, research process in flow chart, criteria of good research, problems encountered by researchers in India.
2. Difference between TEX and LATEX, basics of using latex, latex input files, input file structures, layout of the document, titles, chapter and sections, cross references, foot note, environments, typesetting, building blocks of a mathematical formula, matrices, tables, including encapsulated postscript graphics, bibliography, downloading and installing LATEX packages.
3. Introduction to MATHEMATICA and MATLAB
4. Introduction to origin, basics of importing and exporting data, working with Microsoft excel, graphing, statistics in origin, hypothesis testing, power and sample size, basic linear regression and curve fitting.
5. Error Analysis and Basic Statistics Measuring errors, uncertainties, parent and sample distributions, mean and standard deviation of distribution, types of probability distribution, instrumental and statistical uncertainties, propagation of errors, specific error formulas, method of least square fitting.
6. **Multivariate analysis**: Multiple regression, multiple discriminant analysis, multiple
analysis of variance, canonical correlation analysis, Factor analysis cluster analysis, path analysis. Computational techniques.
7. **Survey of literature**: The students will be required to review literature in their respective disciplines and submit an assignment for evaluation.

REFERENCES:

1. Research methodology (http://www.newagepublishers.com/samplechapter/000896.pdf)

2. The not so short introduction to LATEX by TobianOetiker, Hubert Partl, HreneHyna

and Elisabeth Schlegl, Version 4.16, May 08, 2005 (http://tobi.oetiker.ch/lshort/lshort.pdf)

3. T.Veerarajan and T. Ramachandran "Numerical methods" Tata McGraw Hill, New Delhi, 2008

4. Data reduction and error analysis for physical sciences by Philip R. Bevington and D.

Keith Robinson

(http://www.physast.uga.edu/files/phys3330_fertig/BasicErrorAnalysis.pdf)

19/7/16 Vinay Kanwal. 19/7/2016 19/7/2016

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MPHM-102 Methods in Applied Mathematics

UNIT-I

Integral Equations: Their origin and classification, Relation between differential and Integral equations, IVP AND BVP reducible to Integral equations, Integral equation with separable kernals, Method of successive approximations, Classical Fredolm theory.

UNIT-II

Fourier series and its convergence, Gibbs phenomenon, Integration and Differentiation of Fourier Series, the phase angle form of Fourier series, Complex Fourier series and frequency spectrum, Fourier Integrals, Fourier Cosine and sine Integrals, Complex Fourier Integrals.

UNIT-III

Fourier transforms Properties of Fourier Transform and its Applications, Convolution, Fourier cosine and Sine transforms, Discrete Fourier Transforms, Fast Fourier Transform, Solution of equations, Hankel and Mellin transforms and their Applications.

UNIT-IV

Wavelets: History of wavelets, The Haar wavelets, The Stromberg Wavelet, Wavelet expansion, Multiresolution analysis with Haar wavelets, Periodic wavelets, General Construction of wavelets, Wavelet transform versus Fourier transform.

Suggested Readings/ Books:

1. Ram P. Kanwal: Linear Integral Equations, Academic Press (1971)
2. Abdul J. Jerri: Introduction to Integral Equations with Applications, Monographs and Text Books in Pure and Applied Mathematics, Marcel Dekker, INC (1985)
3. F B Hildebrand: Methods of Applied Mathematics, Dover Publication (1965)
4. Lokenath Debnath and Dambaru Bhatta: Integral Transforms and Their Applications, Second Edition Chapman and Hall/ CRC (2006)
5. Brian Davies: Integral Transforms and Their Applications, Text Book in Applied Mathematics, Vol 41, 3rd Edition, Springer (2002)
6. P. Wojtaszczyk, A Mathematical Introduction to wavelets, London Mathematical Society Students Text, 73, (1999)
7. Veronique Delouille: An Introduction to Wavelet Analysis, Connexions, (2009)
8. Willard Miller, Introduction to the Mathematics of Wavelets, University of Minnesota, (2006)
9. Peter V. O'Neil, Advanced Engineering Mathematics, Thomson.

19/7/16

Vinay Kanwal
19/7/16

Continuum Mechanics
(MPHM-103)

Unit-I

Continuum Hypothesis: Notion of Continuum. Configuration of a Continuum, Mass and Density, Description of motion, Material and Spatial Coordinates

Analysis of Strain: Affine Transformation, infinitesimal Affine Deformation, Geometrical interpretation of the Components of Strain, Strain Quadric of Cauchy, Principal Strains, Invariants, General Infinitesimal Deformation, Examples of strain, Notation, Equations of Compatibility, Finite Deformation

Unit-II

Analysis of Stress: Body and Surface Forces, Stress Tensor, Note on Notation and Units, Equations of Equilibrium, Transformation of Coordinates, Stress Quadric of Cauchy, Maximal Normal and Shear Stresses, Examples of Stresses.

Unit-III

Stress Strain Relations: Hookes law, Generalized Hookes law, Homogeneous isotropic bodies, Elastioc moduli of isotropic bodies, Equilibrium Equations for an isotropic elastic solid, Dynamical equations of an isotropic elastic solid.
The strain energy function and its connection with Hooke's law, Uniqueness of solution of the Boundary-value problems of Elasticity, Saint-Venant's principle.

Unit-IV

Fundamental laws of continuum mechanics: Conservation of mass, Balance of linear momentum, Balance of angular momentum, General solutions of the Equation of Equilibrium, Balance of energy, Entropy inequality, Constitutive Equations

RECOMMENDED BOOKS

1. Sokolnikoff, I.S., Mathematical Theory of Elasticity, Krieger Publishing Company (1983)
2. Chandrasekharaiah and Debnath, Continuum Mechanics, Academic Press (1994).
3. Jog. C. S., Foundations and Applications of Mechanics: volume I: continuum Mechanics, Narosa Publications, (2006).

Advanced Analysis
(MPHM-104)

Unit-I

Distributions: Test functions & Distributions, Some Operations with Distributions, Supports and singular Supports of Distributions, Convolution of functions, Convolution of Distributions, Fundamental solutions, The Fourier Transform, The Schwartz Space, The Fourier Inversion formula, Tempered Distributions.

Unit-II

Sobolev spaces: Definition and basic properties, Approximation by smooth functions, Extension theorems, lmbedding theorems, compactness theorem, Dual spaces, fractional order spaces, trace spaces, trace theory.

Unit-III

Weak solutions of elliptic boundary value problems: Some abstract variational problems, examples of elliptic boundary value problems, Regularity of weak solutions, Examples of Galerkin method, Maximum Principles, eigenvalue problems, Introduction to Finite element methods.

RECOMMENDED BOOKS

S. Kesavan: Topics in Functional Analysis and Applications, New Age Publishers (P) Limited; 2003.
Chap-1,2, and 3.

Advanced Number Theory
(UC-MSM-504-18)

Unit-I

Partitions, Compositions, Ferrers graphs, Jacobi's triple product identity, Congruence properties of $p(n)$,Rogers-Ramanujan identities, Basic hypergeometric series, q-binomial theorem, Sylvester's theorem (Statement only), Heine's transformation (Statement only).

Unit-II

Restricted partitions, q-Gauss theorem, Gaussian polynomials, Bailey's lemma (weak version) (Statement only), Rogers lemma, q-Saalschutz's theorem (Statement only), Finite version of q-Saalschutz's theorem.

Unit-III

Schur's theorem, Gollnitz-Gordon identities, Generalization and various analogues of Rogers-Ramanujan identities, Bailey's lemma (strong version) (Statement only), Watson's q-analogue of Whipple's theorem (Statement only) and its applications in deriving Rogers-Ramanujan identities and Gollnitz-Gordon identities.

Unit-IV

Rank & Crank of a partition, n-n-colour partitions, Conjugate and self-conjugate n-colour partitions, Restricted n-colour partitions, Rogers-Ramanujan type identities for n-colour partitions.

RECOMMENDED BOOKS

1. Agarwal, A.K., Padmavathamma and Subbarao, M.V., *Partition Theory*, Atma Ram & Sons, Chandigarh, 2005.
2. Andrews, G.E., *The Theory of Partitions, Encyclopedia of Mathematics and its Applications* (Addison-Wesley), 1976, Re-issued: Cambridge University Press, Cambridge, 1988.
3. Gasper, G. and Rahman, M., *Basic Hypergeometric Series*, *Encyclopedia of Mathematics and its Applications*, Vol. 35, Cambridge University Press, Cambridge, 1990.
4. Agarwal, R.P., *Resonance of Ramanujan Mathematics*, Vol. 1 (New Age International), 1996.
5. Gupta, H., *Selected Topics in Number Theory*, ABACUS Press, 1980.
6. N.J. Fine, *Basic Hypergeometric Series and Applications*, Mathematical Surveys and Monographs, No. 27, American Mathematical Society, 1988.

Advanced Numerical Methods
(UC-MSM-510-18)

Unit-I

Iterative Methods for Linear Systems & Eigenvalue problem: The classical iterative methods: Jacobi, Gauss-Seidel and Successive Over Relaxation (SOR) methods. Conjugate gradient method. Eigenvalues & eigenvectors: Rayleigh power method & Givens method.

Unit-II

Finite Difference Methods: Explicit and implicit schemes, consistency, stability and convergence, Lax equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

Unit-III

Approximate Methods of Solution: Rayleigh-Ritz, collocation and Galerkin methods, properties of Galerkin approximations, Petrov-Galerkin method, Generalized Galerkin method.

Unit-IV

Finite Element Method (FEM): FEM for second order problems, One and two dimensional problems, The finite elements (elements with a triangular mesh and a rectangular mesh and three dimensional finite elements), Fourth-order problems, Hermite families of elements, iso-parametric elements, numerical integration.

RECOMMENDED BOOKS

1. Jain, M.K, Iyengar, S.R.K. and Jain, R.K., *Numerical Methods for Scientific and Engineering Computation*, 5th Edition, New Age international, 2008.
2. Hoffman Joe D., *Numerical methods for Engineers and Scientists*, McGraw-Hill, 1993.
3. Atkinson, K.E, *An Introduction to Numerical Analysis,* 2^{n} Edition, *John Wiley*, 2004.
4. Gupta R.S., *Elements of Numerical Analysis*, McMillan India, 2009.
5. Seshu P., *Textbook of Finite Element Analysis*, Prentice Hall India, 2003.

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M. Sc. Mathematics is a post graduate level course of the Department of Mathematics which is a 2 years It is consisting of semester system (4 semesters) with two semesters per year.

Programme Code: MMS *(Masters in Mathematical Sciences)*

Eligibility: B.A/B.Sc. with Honours in Mathematics or B.A./B.Sc. (pass course) with Mathematics as one of thesubjects having at least 50% marks in aggregate and at least 55% marks in Mathematics subject.

First Semester **Contact Hours: 2**

Course Code	Course Title	Load Allocation			Marks Distribution			Cr
		L	T	P	Internal	External	Total	
MMS-101	Algebra-I	4	1	0	50	100	150	
MMS-102	Real Analysis-I	4	1	0	50	100	150	
MMS-103	Complex Analysis	4	1	0	50	100	150	
MMS-104	Ordinary Differential Equations & Special functions	4	1	0	50	100	150	
MMS-105	Fundamentals of Computer and C Programming	4	0	0	50	100	150	
MMS-106	Fundamentals of Computer and C Programming Lab	0	0	2	50	-	50	
	Total	20	04	02	300	500	800	

Second Semester **Contact Hours: 27 H**

Course Code	Course Title	Load Allocation			Marks Distribution			Cr
		L	T	P	Internal	External	Total	
MMS-201	Algebra-II	4	1	0	50	100	150	
MMS-202	Real Analysis-II	4	1	0	50	100	150	
MMS-203	Mechanics	4	1	0	50	100	150	
MMS-204	Tensors and Differential Geometry	4	1	0	50	100	150	
MMS-205	Numerical Analysis	4	1	0	50	100	150	
MMs-206	Numerical Analysis Lab	0	0	2	50	-	50	
	Total	20	05	02	300	600	800	

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Third Semester Contact Hours: 27

Course Code	Course Title	Load Allocation			Marks Distribution			(
		L	T	P	Internal	External	Total	
MMS-301	Topology	4	1	0	50	100	150	
MMS-302	Operations Research	4	1	0	50	100	150	
MMS-303	Mathematical Statistics	4	1	0	50	100	150	
MMS-304	Functional Analysis	4	1	0	50	100	150	
MMS-XXX	Elective –I	4	0	0	50	100	150	
MMS-305	Seminar	0	0	2	50	-	50	
	Total	20	05	02	300	500	800	

Fourth Semester Contact Hours: 27 F

Course Code	Course Title	Load Allocation			Marks Distribution			Cı
		L	T	P	Internal	External	Total	
MMS-401	Discrete Mathematics	4	1	0	50	100	150	
MMS-402	Mathematical Methods	4	1	0	50	100	150	
MMS-403	Partial differential equations	4	1	0	50	100	150	
MMS-YYY	Elective –II	4	1	0	50	100	150	
MMS-ZZZ	Elective –III	4	0	0	50	100	150	
MMS-404	Seminar	0	0	2	50	-	50	
	Total	20	05	02	300	500	800	

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Elective –I MMS XXX (Any one subject to be opted)

MMS-501 Fluid Mechanics
MMS-502 Solid Mechanics
MMS-503 Coding Theory
MMS-504 Advanced Complex Analysis

Note1: Student is to adopt one course from the list of Elective II and one course from list of Elective III

Elective – II Courses: MMS 505, MMS 506, MMS 510, MMS 512

Elective – III Courses: MMS 507, MMS 508, MMS 509, MMS 511

MMS-505 Advanced Operations Research
MMS-506 Advanced Fluid Mechanics
MMS-507 Advanced Solid Mechanics
MMS-508 Number Theory and Cryptography
MMS-509 Theory of Linear Operators
MMS-510 Advanced Numerical Methods
MMS-511 Topological Vector Spaces
MMS-512 Fractional Calculus

Note 2:

Instructions for paper setters and candidates:

(a) Eight questions are to be set preferably two questions from the each unit.

(b) The students are required to attempt any five questions. All questions carry equal marks.

(c) Duration of examination is three hours.

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Scheme and Syllabus of

M.Sc. Mathematics Batch 2017 onwards

M.Sc. Mathematics is a postgraduate level course of the Department of Mathematics which is a 2-years course. It is consisting of semester system (4 semesters) with two semesters per year.

Program Code: MSM (Masters of Science in Mathematics)

Eligibility: B.A./B.Sc. with Honors in Mathematics or B.A./B.Sc. (pass course) with Mathematics as one of the subjects having at least 50% marks in aggregate.

First Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM-101	Algebra-I	4	1	0	20	80	100	5
MSM -102	Real Analysis-I	4	1	0	20	80	100	5
MSM -103	Complex Analysis	4	1	0	20	80	100	5
MSM -104	Ordinary Differential Equations and Special Functions	4	1	0	20	80	100	5
MSM -105	Mathematical Methods	4	1	0	20	80	100	5
MSM -106	Introduction to Computer Algebra System (Lab)	0	0	2	50	00	50	1
Total		20	05	02	150	400	550	26

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Second Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM -201	Algebra-II	4	1	0	20	80	100	5
MSM -202	Real Analysis-II	4	1	0	20	80	100	5
MSM -203	Mechanics-I	4	1	0	20	80	100	5
MSM -204	Partial Differential Equations	4	1	0	20	80	100	5
MSM -205	Numerical Analysis	4	1	0	20	80	100	5
MSM -206	Numerical Analysis (Lab)	0	0	2	50	00	50	1
Total		20	05	02	150	400	550	26

Third Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM -301	Topology	4	1	0	20	80	100	5
MSM -302	Number Theory and Cryptography	4	1	0	20	80	100	5
MSM -303	Mathematical Statistics-I	4	1	0	20	80	100	5
MSM -304	Functional Analysis	4	1	0	20	80	100	5
MSM -XXX	Elective-I	4	1	0	20	80	100	5
MSM -305	Seminar	0	0	2	50	-	50	1
Total		20	05	02	150	400	550	26

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Fourth Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM -401	Mechanics-II	4	1	0	20	80	100	5
MSM -402	Mathematical Statistics-II	4	1	0	20	80	100	5
MSM-403	Differential Geometry	4	1	0	20	80	100	5
MSM -YYY	Elective-II	4	1	0	20	80	100	5
MSM -ZZZ	Elective-III	4	1	0	20	80	100	5
MSM -404	Seminar	0	0	2	50	-	50	1
Total		20	05	02	150	400	550	26

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Elective-I MSM XXX (Any one subject to be opted)

MSM -501 Coding Theory

MSM -502 Operations Research

Note1: Student is to adopt one course from the list of Elective-II and one course from list of Elective-III

Elective-II Courses: MSM-503, MSM-504, MSM-505, MSM-506

Elective-III Courses: MSM-507, MSM-508, MSM-509, MSM-510, MSM-511

MSM -503 Advanced Complex Analysis

MSM -504 Advanced Operations Research

MSM -505 Advanced Fluid Mechanics

MSM -506 Advanced Solid Mechanics

MSM -507 Theory of Linear Operators

MSM -508 Advanced Numerical Methods

MSM -509 Topological Vector Spaces

MSM -510 Fractional Calculus

MSM -511 Discrete Mathematics

Note 2:

Instructions for paper setters and candidates:

a) The entire question paper should be distributed into three sections viz. Section-A, Section-B, Section-C.
b) The Section-A should cover the entire syllabus, the Section-B should cover Unit-I & II and the Section-C should cover Unit-III & IV of the syllabus.
c) Section-A should contain eight questions of two marks each. This section should cover the entire syllabus. All questions in this section should be compulsory.
d) Section-B and Section-C should contain three questions each carrying 16 (sixteen) marks.
e) Student should be asked to attempt at least two questions from Section-B and Section-C each.
f) The awards for internal and external examination should be in 20:80 ratio.
g) The Duration of examination is three hours.

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Scheme of the Program:

First Semester

Contact Hours: 28 Hrs.

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
UC-MSM-101-18	Algebra-I	4	1	0	40	60	100	4
UC-MSM-102-18	Real Analysis-I	4	1	0	40	60	100	4
UC-MSM-103-18	Complex Analysis	4	1	0	40	60	100	4
UC-MSM-104-18	Ordinary Differential Equations and Special Functions	4	1	0	40	60	100	4
UC-MSM-105-18	Mathematical Methods	4	1	0	40	60	100	4
UC-MSM-106-18	Introduction to Computer Algebra System (Lab)	0	0	3	50	25	75	3
Total		20	05	03	250	325	575	23

Second Semester

Contact Hours: 28 Hrs.

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
UC-MSM-201-18	Algebra-II	4	1	0	40	60	100	4
UC-MSM-202-18	Real Analysis-II	4	1	0	40	60	100	4
UC-MSM-203-18	Mechanics-I	4	1	0	40	60	100	4

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UC-MSM-204-18	Partial Differential Equations	4	1	0	40	60	100	4
UC-MSM-205-18	Numerical Analysis	4	1	0	40	60	100	4
UC-MSM-206-18	Numerical Analysis (Lab)	0	0	3	50	25	75	3
Total		20	05	03	250	325	575	23

Third Semester

Contact Hours: 25 Hrs.

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
UC-MSM-301-18	Topology	4	1	0	40	60	100	4
UC-MSM-302-18	Number Theory and Cryptography	4	1	0	40	60	100	4
UC-MSM-303-18	Mathematical Statistics	4	1	0	40	60	100	4
UC-MSM-304-18	Functional Analysis	4	1	0	40	60	100	4
UC-MSM-305-18	Mechanics-II	4	1	0	40	60	100	4
UC-MSM-311-18	Seminar	0	0	2	50	0	50	2
Total		20	05	00	200	300	500	22

Fourth Semester **Contact Hours: 27 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution			Credits
			L	T	P	Internal	External	Total	
1.	UC-MSM-401-18	Differential Geometry	4	1	0	40	60	100	4
2.	UC-MSM-WWW-18	Elective	4	1	0	40	60	100	4
3.*	UC-MSM-XXX-18 UC-MSM-YYY-18 UC-MSM-ZZZ-18	Elective	4	1	0	40	60	100	12
	UC-MSM-411-18	Dissertation	-	-	12	200	100	300	
4.	UC-MSM-412-18	Seminar	0	0	2	50	0	50	2
		Total						550	22

TOTAL NUMBER OF CREDITS = 90

Note*: Students may opt either three Elective Theories or Dissertation.

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LIST OF DEPARTMENTAL/INTERDISCIPLINARY ELECTIVES

Elective- UC-MSM-WWW-18, UC-MSM-XXX-18, UC-MSM-YYY-18, UC-MSM-ZZZ-18 (Any one subject to be opted)

MSM-501-18 Discrete Mathematics

MSM-502-18 Coding Theory

MSM-503-18 Operations Research

MSM-504-18 Advanced Number Theory

MSM-505-18 Advanced Complex Analysis

MSM-506-18 Advanced Operations Research

MSM-507-18 Advanced Fluid Mechanics

MSM-508-18 Advanced Solid Mechanics

MSM-509-18 Theory of Linear Operators

MSM-510-18 Advanced Numerical Methods

MSM-511-18 Topological Vector Spaces

MSM-512-18 Fractional Calculus

Examination and Evaluation

Theory			
S. No.	**Evaluation criteria**	**Weightage in Marks**	**Remarks**
1	Mid term/sessional Tests	24	Internal evaluation (40 Marks) MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
2	Attendance	6	
3	Assignments	10	
4	End semester examination	60	External evaluation

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MMS-101: ALGEBRA-I

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Unit-I

Review of basic concept of groups, automorphisms and inner automorphisms of a group, Normalizer and Centralizer, Conjugate elements and conjugacy classes, class equation of a finite group and its applications, Cauchy's theorem, Sylow's theorems, Review of Permutation Groups, Alternating Group A_n, simplicity of A_n, Direct Products, fundamental theorem of finitely generated abelian groups, Invariants of finite abelian groups.

Unit-II

Normal and sub normal series, Composition series, Zassenhaus's Lemma, Scherer's refinement theorem and Jordan-Holder theorem, Derived group, Solvable groups, Nilpotent groups, fundamental theorem of arithmetic.

Unit-III

Rings, Subrings, ideals, Sum and direct sum of ideals, Maximal, Prime, Nilpotent & Nil ideals, Statement of Zorn's Lemma, Rings of Fractions, Field of quotients of an integral domain.

Unit-IV

Factorization Theory in Integral Domains, Divisibility, Rings of Gaussian integers, Unique Factorization Domain (UFD), Principal Ideal Domain (PID), Euclidian Domain(ED) and their relationships, Polynomial rings over unique factorization domains.

BOOKS RECOMMENDED

1. Bhattacharya, P.B., Jain, S.K. &Nagpal, S.R.: Basic Abstract Algebra, Cambridge University Press, 1997.
2. Surjeet Singh, QuzaiZameeruddin: Modern Algebra, Vikas Publishing House , New Delhi,8th edition,2006.
3. I.N. Herstein: Topics in Algebra, 2nd edition, Wiley Eastern, 1975.

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Department of Mathematical Sciences
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MMS-102: REAL ANALYSIS-I

L T P
4 1 0

UNIT-I

Elementary set theory, finite, countable and uncountable sets. Metric spaces: definition and examples, open and closed sets, compact sets, elementary properties of compact sets, k- cells, compactness of k cells, compact subsets of Euclidean space R^k. Perfect sets, Cantor set, separated sets, connected sets in a metric space, connected subsets of real line.

UNIT-II

Convergent sequences (in Metric spaces), Cauchy sequences, subsequences, complete metric space, Cantor's intersection theorem, category of a set and Baire's category theorem.Examples of complete metric space, Banach contraction principle.

UNIT-III

Limits of functions (in Metric spaces), continuous functions, continuity and compactness, continuity and connectedness, discontinuities, monotonic functions, uniform continuity.

UNIT-IV

Riemann Stieltje'sIntegral : definition and existence of integral, properties of integral, integration and differentiation, Fundamental theorem of Calculus, $1^{st}$and 2^{nd} mean value theorems for Riemann Stieltje's integral

BOOKS RECOMMENDED

1. Walter Rudin, Principles of Mathematical Analysis, 3^{rd} edition, McGraw Hill, Kogakusha, 1976, International student edition

2. H. L. Royden, Real Analysis, 3^{rd} edition, Macmillan, New York & London 1988.

3. Tom M. Apostol, Mathematical Analysis, Addition –Wesley.

4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Ltd (2008).

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MMS 103: COMPLEX ANALYSIS

L T P
4 1 0

Unit-I

Function of complex variable, continuity and differentiability, analytic functions, conjugate function, harmonic function. Cauchy Riemann equation (Cartesian and polar form).Construction of analytic functions.Stereographic projection and the spherical representation of the extended complex plane.

Unit-II

Complex line integral, cauchy's theorem, cauchy's integral formula and it's generalized form. cauchy's inequality, Poisson's integral formula, Morera's theorem, Liouville's theorem, power series, Taylor's theorem, Laurent's theorem. Fundamental theorem of algebra and Rouche's theorem, Maximum modulus principle, Schwarz lemma.

Unit-III

Zero's, Singularities, residue at a pole and at infinity. Cauchy's Residue theorem, Jordan's lemma, integration round unit circle, Evaluation of integrals.

Unit-IV

Conformal transformations, bilinear transformations, critical points, fixed points, Problems on çross-ratio and bilinear transformation.

BOOKS RECOMMENDED

1. Complex Analysis (2nd Edition) – L. V. Ahlfors, McGraw-Hill International Student Edition, 1990.
2. An Introduction to the Theory of functions of a complex Variable – E. T. Copson, Oxford university press, 1995.
3. An Introduction To Complex Analysis – A. R. Shastri, Macmillan India Ltd., 2003.
4. Complex Variables and Applications – S. Ponnusamy, and H. Silverman, Birhkäuser, 2006.
5. Complex Variables and Applications- R Churchill R, Brown J.W: 6thedition , New york, McGraw-Hill 1996.

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MMS 104: ORDINARY DIFFERENTIAL EQUATIONS AND SPECIAL FUNCTIONS

L	T	P
4	1	0

UNIT-I

Review of linear differential equations with constant & variable coefficients, Power series solution of differential equation about an ordinary point, Solution about regular singular points: The method of Frobenius, System of linear differential equations, An operator method for linear system with constant coefficients, Phase plane method.

UNIT-II

Homogeneous Linear systems with constant coefficients, Complex eigenvalues, repeated eigenvalues, Fundamental Existence and Uniqueness theorem, existence and Uniqueness theorem for system and Higher order equations, Linear homogeneous boundary value problems: Eigenvalues and eigen functions.

UNIT-III

Bessel equation and Bessel functions, Recurrence relations and orthogonal properties., Series expansion of Bessel Coefficients, Integral expression, Integral involving Bessel functions, Modified Bessel function, Ber and Bei functions, Asymptotic expansion of Bessel Functions , Legendre's differential equations, Legendre Polynomials ,Rodrigue's formula, Recurrence relations and orthogonal properties.

UNIT-IV

The Hermite polynomials, Chebyshev's polynomial, Laugrre's polynomial: Recurrence relations, generating functions and orthogonal properties

BOOKS RECOMMENDED

1. S L Ross, Differential Equations, Third Edition, John Wiley & Sons (2004)
2. W E Boyce, R C Diprima, elementary Differential Equations and Boundary Value problems, 4th Edition, John Wiely and Sons (1986)
3. I N Sneddon, Special Functions of Mathematical Physics and Chemistry, Edinburg, Oliver & Boyd (1956)
4. G Andrews, R Askey& R Roy, Special Functions, Cambridge (1999)
5. L Andrews, Special Functions for Engineers and Applied Scientists, Mcmillan (1985)
6. W W Bell, Special Functions for Scientists and Engineers, Dover, (1986)

MMS 105: FUNDAMENTALS OF COMPUTER AND C PROGRAMMINGL T P
4 0 0

Unit I

Computer's general concepts: historical overview , technological advantages in computers, shape of today's computer as a system, CPU, primary memory , secondary storage devices, input devices, output devices, significance of software system , categories of software system software, applications software, comiler, interpreter , utility program, binary arithmetic for integer and fractional numbers, operating system and its significance.

Unit II

Character sets for c , constants and variables, arithmetic expressions input and output statements, comments, data types, statement labels, built in functions and libraries, logical if-else and nested if-else statement, switch , break, continue , go to statements, preprocessor in c

Unit III

While , for and do while loops in c , arrays, array variables, syntax rules, use of multiple subscripts in arrays, reading and writing multi-dimensional araays, storage classes structures and union

Unit IV

Function definition, function prototypes, Arguments, call by value, call by reference, passing array variable to a function, pointer variables, relationship of pointer and array, passing pointer variable to a function, strings handling, and file processing operations in c

BOOKS RECOMMENDED

1. Computer Programming in C – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2005.
2. Computer Applications of Mathematics and Statistics – A. K. Chattapadhyay and T. Chattapadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.
3. The C Programming Language – B. W. Kernighan and D. M. Ritchie, Prentice Hall, India, 1995.
4. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

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MMS 106: FUNDAMENTALS OF COMPUTER AND C PROGRAMMING LabL T P

0 0 2

The following programs are to be practiced:

1. Determination of roots of quadratic equations, $Ax^2+Bx+C=0$,
2. Arranging given set of numbers in increasing/decreasing order, calculation of Mean, Mode, Median.
3. Evaluation of sum of power series eg. e^x, sin x, cos x, log (1 + x).
4. Calculation of GCD/LCM of two integers.
5. Evaluation of factorial of a positive integer and evaluation of binomial coefficients.
6. Generation of twin primes, random numbers.
7. Calculation of Coefficient of Correlation.
8. Computation of scalar product of vectors.
9. Addition and multiplication of matrices.
10. Evaluation of Determinants.
11. Inversion of matrices.
12. Solution of System of linear equations.
13. Writing a given number in words using function.
14. Arranging a set of names in alphabetical order.

BOOKS RECOMMENDED

1. Computer Programming in C – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2005.
2. Computer Applications of Mathematics and Statistics – A. K. Chattapadhyay and T. Chattapadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.
3. The C Programming Language – B. W. Kernighan and D. M. Ritchie, Prentice Hall, India, 1995.
4. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

Candidates are required to perform at least 10-12 practicals

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MMS-201: ALGEBRA-IIL T P
4 1 0

Unit-I

Modules, sub modules, free modules, Quotient modules, Isomorhism theorem, Direct sums, Modules associated with a linear operator, Cyclic modules, Noetherian and Artinian modules and rings.

Unit-II

Field extension: Finite, Algebraic and Transcendental extensions, Simple, Separable and inseparable Extensions, Algebraically Closed fields, Splitting fields, Existence & uniqueness, Normal Extensions, Finite Fields.

Unit-III

Galois extensions , Galois group of an extension and Fundamental theorem of Galois Theory

Unit-IV

Review of vector spaces, Dual space , Dual basis, Reflexivity ,Annihilators, inner product spaces, orthogonal and orthonormal basis ,Gram schmidthorthogonalisation process.

BOOKS RECOMMENDED

1. Bhattacharya, P.B., Jain, S.K. &Nagpal, S.R.: Basic Abstract Algebra, Cambridge University Press, 1997.
2. Surjeet Singh, QuzaiZameeruddin: Modern Algebra, Vikas Publishing House , New Delhi,8th edition,2006.
3. I.N. Herstein: Topics in Algebra, 2nd edition, Wiley Eastern, 1975.

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MMS 202: REAL ANALYSIS-IIL T P
4 1 0

UNIT-I

Preliminaries, Lebesgue outer measure. Measurable sets. Regularity, Lebesgue measure, non-measurable sets. Measurable functions. Borel and Lebesgue measurability, Littlewood's three principles.

UNIT-II

The Lebesgue integral of a simple function and bounded function, comparison of Riemann and Lebesgue integral, Bounded convergence theorem, Integral of non -negative functions, Fatou's Lemma, Monotone convergence theorem, The general Lebesgue Integral, Lebesgue convergence theorem, Integration of series.

UNIT-III

Vitali,s Lemma, The Four derivates, continuous non differentiable functions. Functions of bounded variation.Lebesgue differentiation theorem.Differentiation and integration. The Lebesgue set

UNIT-IV

Convex functions, Jensen's inequality,TheL^p-spaces, Holder and Minkowski inequalities. Convergence in mean, Completeness of L^p, Approximation in L^p spaces.

BOOKS RECOMMENDED

1. H.L. Royden, *Real Analysis,* Macmillan, New York, 1988.
2. G.de Bara, Measure Theory and Integration, Ellis Horwood Limited, England, 2nd Edition 2003.
3. G.B. Folland, *Real Analysis,* second edition, John Wiley, New York, 1999.
4. E. Kreyszig Introductory Functional Analysis with Applications, John Wiley, 1989.

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MMS 203: MECHANICS

L T P
4 1 0

Unit-I

Generalized coordinates, Holonomic and non-holonomic systems scleronomic and rhenomic systems, Generalized potential, lagrange's equation of first kind and second kind uniqueness of solution, Energy equation for conservative field.

Unit-II

Hamilton variables, donkin's theorem ,Hamilton canonical equation, cyclic coordinates, Routh's equation , Poisson bracket , Poisson's identity , Jacobi -Poisson theorem, Hamilton's principle, principle of least action Poincare- Cartan integral invariant, whittaker's equations lee hwachung's theorem.

Unit-III

Small oscillations of conservative system Lagrange's equation for small oscillations, Nature of roots of frequency equation, Principle oscillations. Normal coordinates, Canonical transformations, free canonical transformations, Hamilton- Jacobi equation, and Jacobi theorem.

Unit-IV

Method of separation of variables, lagrange's bracket' condition of Canonical character of transformation in terms of Lagrange's bracket and Poisson's Bracket. Invariance of Lagrange's bracket and Poisson's bracket and canonical transformation, Lagrange's theorem on the stability of equilibrium position, Lyapunov theorem, Nadchetayev theorem, asymptotic stability of an equilibrium position.

BOOKS RECOMMENDED

1. F. Gantmacher. Lectures in analytic mechanics . Mir Publisher , Moscow, 1975.
2. H. goldstien, c.ppoole and j.l. sofco, classical mechanics , third edition, Addison Wesely, 2002.
3. Mechanics – L. D. Landau and E. M. Lipshitz, Pergamon Press, Oxford, 1976.
4. Lectures on Mechanics – J. E. Marsden, Cambridge University Press, 1992.

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MTS 204: TENSORS AND DIFFERENTIAL GEOMETRY

L T P
4 1 0

UNIT-I

Systems of Different orders - Summation Convention - Kronecker Symbols - Transformation of coordinates in Sn - Invariants - Covariant and Contravariant vectors - Tensors of Second Order - Mixed Tensors - Zero Tensor - Tensor Field - Algebra of Tensors - Equality of Tensors - Symmetric and Skew – symmetric tensors - Outer multiplication, Contraction and Inner Multiplication - Quotient Law of Tensors - Reciprocal Tensor of Tensor - Relative Tensor - Cross Product of Vectors.

UNIT-II

Riemannian Space - Christoffel Symbols and their properties ,Covariant Differentiation of Tensors - Riemann - Christoffel Curvature Tensor - Intrinsic Differentiation.

UNIT-III

Definition of a surface - curves on a surface - Surface of revolution - Helicoids - Metric - Direction coefficients - families of curves - Isometric correspondence - Intrinsic properties.

UNIT-IV

Geodesics - Canonical geodesic equations - Normal property of geodesics - Existence Theorems - Geodesic parallels - Geodesics curvature - Gauss - Bonnet Theorem - Gaussian curvature - surface of constant curvature.

BOOKS RECOMMENDED

1. Struik, D.T. Lectures on Classical Differential Geometry, Addison - Wesley, Mass. 1950.
2. Kobayashi. S. and Nomizu. K. Foundations of Differential Geometry, Interscience Publishers, 1963.
3. Wilhelm Klingenberg: A course in Differential Geometry, Graduate Texts in Mathematics, Springer-Verlag 1978.
4. J.L.Synge and A.Schild, Tensor Calculus, Toronto, 1949.
5. A.S.Eddington. The Mathematical Theory of Relativity, Cambridge University Press, 1930.

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MTS 205: NUMERICAL ANALYSIS

L T P
4 1 0

Unit-I

Numerical Computation and Error Analysis: Numbers and their accuracy, Floating point arithmetic, Errors in numbers, error estimation, general error formulae, error propagation in computation. Algebraic and Transcendental Equations: Bisection method, iteration method, Regula- Falsi method, secant method, Newton-Raphson method. Convergence of these methods. Lin-Bairstow's method, Muller method ,Graeffe's root squaring method , solution of system of nonlinear equations, complex roots by Newton – Raphson method.

Unit-II

System of Linear Algebraic Equations: Guass elimination method, Gauss – Jordon method , LU factorization method , Jacobi and Gauss-Seidal methods, Convergence of iteration methods, Round-off errors and refinement, ill- conditioning, Partitioning method, Inverse of Matrices. Eigen values and eigen vector: Rayleigh Power method , Given's method and House –Holder method.

Unit-III

Interpolation: Finite differences, Newton interpolation formulae, Gauss, Stirling and Bessel'sformulae, Lagrange's, Hermits and Newton's divided difference formulae. Numerical differentiation and integration: differentiation at tabulated and non-tabulated points, maximum and minimum values of tabulated function, Newton-Cotes formulae-Trapezoidal, Simpson's, Booles and Weddle rules of integration , Romberg integration , Gaussian integration, Double integration by Trapezoidal and Simpson rules.

Unit-IV

Ordinary Differential Equations: Taylor series and Picard's methods, Euler and modified Euler methods, Runge –Kutta methods, Predictor- Corrector methods: Adam-Beshforth and Miline methods. Error analysis and accuracy of these methods. Solution of simultaneous and higher order equations, Boundary values problems: Finite difference and shooting methods

BOOKS RECOMMENDED

1. V. Rajaraman, Computer Oriented Numerical Analysis, Prentice-Hall of India Pvt. Ltd., 2002.
2. J.N. Sharma, Numerical Methods for Engineers and Scientists(2^{nd} edition), Narosa Publ. House New Delhi/Alpha Science international, Ltd, Oxford UK 2007.
3. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, New Delhi, 1999.

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4. B. Bradie: A friendly introduction to Numerical Analysis.Pearson Prentice Hall 2006
5. K. E. Atkinson, Introduction to Numerical Analysis (2nd edition), John Wiley,1989.
6. S. D. Conte and C. De Boor, Elementary Numerical Analysis: An Algorithmic Approach (3rd edition), McGraw Hill, New York, 1980.
7. J. B. Scarborough,Numerical Mathematical Analysis, Oxford & IBH Publishing Co., 2001.

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MTS 206: NUMERICAL ANALYSIS LAB

L T P
0 0 2

The following programs of following methods are to be practiced:

1. To find a real root of an algebraic/ transcendental equation by using Bisection method.
2. To find a real root of an algebraic/ transcendental equation by using Regula-Falsi method.
3. To find a real root of an algebraic/ transcendental equation by using Newton-Raphson method.
4. To find a real root of an algebraic/ transcendental equation by using Iteration method.
5. Implementation of Gauss- Elimination method to solve a system of linear algebraic equations.
6. Implementation of Jacobi's method to solve a system of linear algebraic equations.
7. Implementation of Gauss-Seidel method to solve a system of linear algebraic equations.
8. To find differential coefficients of 1st and 2nd orders using interpolation formulae.
9. To evaluate definite integrals by using Newton - Cotes integral formulae.
10. To evaluate definite integrals by using Gaussian Quadrature.
11. To evaluate double integrals by using Trapezoidal and Simpson method.
12. To compute the solution of ordinary differential equations with Taylor's series method.
13. To compute the solution of ordinary differential equations by using Euler's method.
14. To compute the solution of ordinary differential equations by using Runge -Kutta methods.
15. To compute the solution of ordinary differential equations by using Milne-Simpson method.

BOOKS RECOMMENDED

1. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw Hill, New Delhi, 1999.
2. J N Sharma, Numerical Methods for engineers and Scientists (2nd Edn) Narosa Publishing House, New
3. Delhi/ Alpha Science International Ltd. Oxford UK, 2007.
4. Conte and de Boor, Numerical Analysis, McGraw Hill, New York, 1990
5. John H. Mathews, Numerical Methods for Mathematics, Science and Engineering (2nd Edn.), Prentice
6. Hall, New Delhi, 2000

Instructions for paper setters and candidates:

Candidates are required to atleast perform at least 10-12 Practical's are to be completed in asemester

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TOPOLOGY (MS-301)

L T P
4 1 0

Unit-I

Introduction topological spaces, closed sets, Closure, Dense subsets, neighborhoods, interior, exterior and boundary, Accumulation points and derived sets. Bases and subbases, Subspaces and relative Topology, Alternative methods of defining a Topology in terms of Kuratowski closure operator and neighborhood systems.

Unit-II

Open mappings and closed mappings, Continues functions and homomorphism's, Compactness and local Compactness. One -point compactification , connected and arc-wise connected spaces, Components and Locally connected spaces.

Unit-III

T_0 and T_1 spaces, T_2 spaces and sequences . Hausdorffness of one point compactification, Axioms of Countability andSeperability, Equivalence of Separable , second Axiom and Lindelof properties in a metric spaces. Equivalence of compact and countably compact sets in metric spaces.

UNIT -IV

Regular and completely regular, Normal and completely normal spaces. Meric spaces as T_2, completely normal and first axiom spaces , Urysohn's Lemma , Tietze Extension Theorem.

BOOKS RECOMMENDED

1.Topology, a first course – J. R. Munkres, Prentice-Hall of India Ltd., New Delhi,2000.
2. An introduction to general topology (2nd edition) – K. D. Joshi, Wiley Eastern Ltd. New Delhi, 2002.
3. G.F Simmons : Introduction to topology and Modern Analysis.
4. General Topology – J. L. Kelley, Springer Verlag, New York, 1990.
5. Basic Topology – M.A. Armstrong, Springer International Ed. 2005.

OPERATIONS RESEARCH (MS-302)

L T P
4 1 0

Unit-I

Formulation of linear programming problem (LPP) -graphical method, Basic Feasible Solution, Extreme Points, Convex set, Convex linear combination, optimal solution of LPP using Simplex , Big-M and two phase methods, Exceptional cases in LPP i.e., Infeasible, unbounded, alternate and degenerate solutions.

Unit-II

General Primal-Dual pair, Formulating a dual problem, Weak and strong duality theorems, Complementary slackness theorem, Dual simplex method, Economic interpretation of primal-Dual problems. Sensitivity analysis: change in right hand side of constraints, change in the objective function and coefficient matrix addition and deletion of constraint and variables.

Unit III

Initial basic Feasible solution of transportation problem, Balanced and unbalanced transportation problems ,Optimal solutions of transportation problem using U-V /MODI methods, Assignment problems; Mathematical formulation of assignment problem, typical assignment problem, the traveling salesman problem, Test for optimality, degeneracy, Project management with critical path method.

Unit-IV

Concept of convexity and concavity, Maxima and minima of convex functions,Single and multivariate unconstrained problems, constrained programming problems, Kuhn-Tucker conditions for constrained programming problems, Quadratic programming, Wolfe's method.

BOOKS RECOMMENDED

1.Taha, H.A., Operations Research-An Introduction, PHI (2007).

2. KantiSwarup, P.K. Gupta and Man Mohan, Operations Research ,Sultan Chand & Sons, Ninth Edition (2002).

3. Friderick S. Hillier and Gerald J. Lieberman, Operations Research ,Holden-Day Inc,USA,econd Edition (1974)

4.Bazaraa, M.S., Sherali, H.D., Shetty, C.M., Nonlinear Programming: Theory and Algorithms, John Wiley and Sons, (1993).

5.Chandra, S., Jayadeva, Mehra, A., Numerical Optimization and Applications, Narosa Publishing House, (2013).

MATHEMATICAL STATISTICS (MS-303)

L T P
4 1 0

Unit I

Classical and axiomatic approach to the theory of probability, additive and multiplicative law of probability, conditional probability and Bayes theorem.Random variable, function of random variable, and their distributions, probability mass function, probability density function, cumulative distribution function.

Unit II

Two dimensional random variables, joint, marginal and conditional distributions, independence of random variables, expectation, conditional expectation, moments, product moments, probability generating functions, moment generating function and its properties. Chebyshev's, Markov, Jenson, Techebyshey's, inequalities, stochastic convergence, central limit theorem.characteristic function and its elementary properties.

Unit III

Study of various discrete and continuous distributions, Binomial, Poisson, Geometric, Hyper geometric, Multinomial. Uniform, Exponential, Normal distributions, Gamma distribution,cauchy, exponential, Beta and gamma distributions, Bivariate normal distribution and distribution of order statistics and range.

Unit IV

Concept of sampling distribution and its standard error, Derivation of sampling distributions of Chi-square, t and F distribution of sample mean and sample variance Testing of hypotheses, fundamental notions important tests based on normal distributions, Tests of significance: tests based on normal distribution, Chi-square, t and F statistic. Analysis of variance: One way and two way classifications.

BOOKS RECOMMENDED

1. Hogg, R.V &Craige: Introduction to Mathematical Statistics. 7th edition(2005)
2. Mckean, J.W. and Craig, A.T.,Mukhopadhyay, P : Mathematical Statistics.(2000)
3. S.C. Gupta and V.K. Kapoor, Fundamental of Mathematical Statistics 7th ed., (1990)
4. Goon, Gupta and Das Gupta, Fundamentals of Statistics, Edition, 5. Publisher, World Press, 1975.
5. Rohatgi V.K.: Introduction to probability theory & Mathematical Statistics 2009.

FUNCTIONAL ANALYSIS (MS-304)

L T P
4 1 0

Unit-I

Normed linear spaces, Banach spaces, properties of normed spaces, finite dimensional normed spaces and subspaces, linear operator, bounded and continuous linear operators, linear functionals, normed spaces of operators

Unit-II

Equivalent norms, conjugate spaces, Reflexivity. Hahn-banach theorems for real/complex vector spaces and normed spaces, application to bounded linear functional on C [a,b].

Unit-III

Uniform boundedness theorem, open mapping theorem, closed graph theorem, Projections on Banach spaces.

Unit-IV

Inner product spaces, Hilbert spaces, properties of inner product spaces, orthogonal complements, orthonormal sets , Hilbert – adjoint operator, self-ad joint, unitary and normal operators.

BOOKS RECOMMENDED

[1] G.F.Simmons: Introduction to topology and modern Analysis (2008)

[2] Walter Rudin, Functional Analysis, International Series in Pure and Applied Mathematics, McGraw-Hill,inc.,1991.

[3] Erwin Kreyszig, introductory Functional Analysis with Applications, John Wiley and Sons(Asia),Pvt.Ltd.,2006.

[4] George Bachman and Lawrence Narici, Functional Analysis, Dover, 2000.

[5] John B. Conway, A course in Functional Analysis, second edition, Springer-Verlag, 2006.

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DISCRETE MATHEMATICS (MS-401) L T P
4 1 0

Unit-I

Mathematical Logic: Basic logical operations, conditional and bi-conditional statements, tautologies, contradiction, predicate calculus and its inference theory.

Recursion and Recurrence Relations: Polynomial expressions, telescopic form, recursion theorem, closed form expression, generating function, solution of recurrence relation using generating function, recursion.

Unit-II

Lattices and Boolean Algebra: Introduction to Binary relations, equivalence relations and partitions, Partial order relations, Hasse diagram.Lattices as partially ordered sets, properties, lattices as algebraic systems, sub lattices, direct products, Homomorphism, some special lattices. Boolean algebra as lattices, Boolean identities, sub-algebra, Boolean forms and their equivalence, sum of product, product of sum of canonical forms. Applications of Boolean algebra to circuit theory.

Unit-III

Graph Theory: Directedgraphs, undirected graphs, paths, circuits, cycles, sub-graphs, induced Sub graphs, degree of vertex, connectivity, planner graph, complete graph, complete bi-partitegraph, matrix representation of graph, adjacency and incidence matrix for graph, Eulerian paths and circuits, Trees and Coloring of the graph, Rooted tree, search tree, tree traversals, spanning trees, minimal spanning trees, Kruskal's algorithm. Chromatic number and polynomial, four-color Theorem(statement only).

Unit-IV

Algebraic Structures: Review of groups, codes and group codes, cyclic codes and coding methods based on entropy, Application of algebraic structure to error corrections and detection codes, discrete codes and first coding theorem.

BOOKS RECOMMENDED:

1. J.P. Tremblay and R.P. Manohar ,Discrete Mathematics with Applications to Computer Science, Tata McGraw Hill , 2008.
2. Ram, Babu, Discrete Mathematics, Pearson Education, (2007).
3. F. Harary, Graph Theory, Narosa, 1995
4. Doerr, Alan and Levsseur, K., Applied Discrete Structures for Computer Science, Galgotia Publication, 2005
5. Liu, C.L, Elements of Discrete Mathematics, Tata McGraw Hill , 2008 3rd Edition
6. Grimaldi, R.P and Ramana, B.V., Discrete and Combinatorial Mathematics-An Applied Introduction, Pearson education (2004) 5th ed.
7. Seymour Lipschultz, "Theory and Practice of Data Structures", McGraw-Hill, 1988.

MATHEMATICAL METHODS (MMS-402)L T P
4 1 0

UNIT I

Integral Transforms: Definitions and properties of Laplace transform, inversion formula convolution, Laplace transform of unit step function and impulsive function, application to ordinary and partial differential equations; Fourier transform, properties of Fourier transform, inversion formula, convolution, Parseval's equality; Fourier transform of generalized functions, application of transforms to heat wave and Laplace equation. Hankel Transforms and its applications in boundary value problems.

UNIT II

Integral Equations: Integral equations of Fredholm and Volterra type, solution by successive substitution and successive approximation, integral equations with degenerate kernels. Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems, integral equations with symmetric kernel, Eigen values and Eigen functions of integral equations and their simple properties.

UNIT III

Calculus of Variations: The extreme of functionals and its properties, variation of functional, Euler equation in one and several independent variables, sufficient conditions for the extremum of a functional, moving end problems, variation problems with constraints- problem of geodesics and isoperimetric.

UNIT IV

Eigen Value Problems: Ordinary differential equations of the Sturm-Liouville Problem, eigen values and eigen functions, expansion theorem, extrema properties of the eigen values of linear differential operators, formulation of the eigen value problem of a differential operator as a problem of integral equation.

BOOKS RECOMMENDED:

1. The Use of Integral Transforms – I. N. Sneddon, Tata McGraw Hill, 1985
2 Fourier Transforms – R. R. Goldberg, Cambridge University Press, 1970.
3 Laplace Transform Theory – M. G. Smith, Van Nostrand Inc., 2000.
4. Calculus of Variation- L. Elsegolc, Dover Publications, 2010
5. Kenwal, Ram P., Linear Integral Equation; Theory and techniques, Academic Press, 1971
6. Hildebrand, F.B., Methods of applied mathematics, Dover Publications, **(Latest Reprint)**

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PARTIAL DIFFERENTIAL EQUATIONS (MMS-403)

L T P
4 1 0

UNIT I

First Order PDE: Definition of PDE, origin of first-order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution.

UNIT II

Second Order PDE: Origin of second order PDE, linear second order PDE with constant coefficients, linear second order PDE with variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order.

UNIT III

Method of Solution: Separation of variables in a PDE; Laplace, wave and diffusion equations, Elementary solutions of Laplace equations.

UNIT IV

Applications of PDE: Wave equation, the occurrence of wave equations, elementary solutions of one dimensional wave equation; vibrating membranes, three dimensional problems. Diffusion equation, resolution of boundary value problems for diffusion equation, elementary solutions of diffusion equation.

BOOKS RECOMMENDED:

1. Elements of Partial Differential Equation (3rd edition) – I. N. Sneddon, McGraw Hill Book Company, 1998.

2. Partial Differential Equations (2nd edition) – E. T. Copson, Cambridge University Press, 1995.

3. Partial Differential Equations: An Introduction [Hardcover]Walter A. Strauss ,(2nd edition) 2007.

4. J.N. Sharma and K. Singh, Partial differential equations for engineers and scientists, 2nd Edition, Narosa Publication House, New Delhi, 2009

5. Sankara Rao, Introduction to partial differential equations, PHI,2010.

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FLUID MECHANICS (MMS-501)

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Unit-I

Lagrangian and Eulerian methods, equation of continuity, stream lines. Path lines and streak lines, velocity potential and stream function, irrotational and rotational motions.

Unit-II

Euler's equation, Bernoulli's equation, equations referred to moving axes, impulsive actions, vortex motion and its elementary properties, motions due to circular and rectilinear vortices, Kelvin's proof of permanence.

Unit-III

Irrotational motion in two-dimensions, complex-velocity potential sources, sinks, doublets and their images, conformal mapping.

Unit-IV

Stress components in a real fluid. Navier- Stokes equations of motion. Plane Poiseiuille and Couette flows between two parallel plates. Flow through a pipe of uniform cross section in theform of circle, annulus, Theory of lubrication.

BOOKSRECOMMENDED

1. Yuan S.W., Foundations of Fluid Mechanics, Prentice Hall of India Private Limited (1976).
2. Chorlton F., Textbook of Fluid Dynamics, C. B. S. Publishers (2005).
3. Besant W.H. and Ramsay A.S., Treatise of Hydro Mechanics, Part II, CBS Publishers (2004).
4. Rathy R.K., An Introduction to fluid Dynamics, Oxford and IBH Publishing Company (1976).

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SOLID MECHANICS (MMS 502) **L T P**
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Unit-I

Analysis of Strain: Affine transformations. Infinitesimal affine deformation.Geometrical interpretation of the components of strain.Strain quadric of Cauchy. Principal strains and invariants. General infinitesimal deformation.Equations of compatibility, Finite deformations.Examples of uniform dilatation, simple extension and shearing strain.

Unit-II

Analysis of Stress: Body and surface forces, stress tensor, equations of equilibrium, transformation of coordinates, stress quadric of Cauchy. Principal stress and invariants.Maximum normal and shear stresses, examples of stresses.

Unit-III

Equations of Elasticity: Generalized Hooke's law, homogeneous isotropic bodies, Elastic moduli for isotropic bodies. Equilibrium and dynamic equations for an isotropic elastic solid.Beltrami-Michell compatibility equations.

Unit-IV

Boundary value problems of elasticity: Strain Energy, Strain energy function,Uniqueness of solution of the boundary-value problems of elasticity, Saint-Venant's Principle, Bounds on the elastic constants, Related Integral theorems, Principle of virtual work, Principles of minimum potential and complementary energy.

BOOKS RECOMMENDED:

1. I.S. Sokolnikoff, *Mathematical Theory of Elasticity,* Tata McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. Martin, H. Sadd, *Elasticity, Theory Applications and Numerics,* Elsevier Academic Press, UK, 2006.

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CODING THEORY (MMS-503)

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Unit-I

Introduction to Coding Theory: Code words, Distance and weight function, Nearest-neighbour decoding principle, Error detection and correction, Matrix encoding techniques, Matrix codes, Group codes, Decoding by coset leaders, Generator and parity check matrices, Syndrom decoding procedure, Dual codes.

Unit-II

Linear Codes: Linear codes, Matrix description of linear codes, Equivalence of linear codes, Minimum distance of linear codes, Dual code of a linear code, Weight distribution of the dual code of a binary linear code, Hamming codes.

Unit-III

BCH Codes: Polynomial codes, Finite fields, Minimal and primitive polynomials, Bose-Chaudhuri-Hocquenghem codes.

Unit-IV

Cyclic Codes: Cyclic codes, Algebraic description of cyclic codes, Check polynomial, BCH and Hamming codes as cyclic codes.Maximum distance separable codes, Necessary and sufficient conditions for MDS codes, Weight distribution of MDS codes, An existence problem, Reed-Solomon codes.

BOOKS RECOMMENDED

1. Vermani L R, Elements of Algebraic Coding Theory, Chapman and Hall (1996).
2. Vera P., Introduction to the Theory of Error Correcting Codes, John Wiley and Sons (1998).
3. Roman Steven, Coding and Information Theory, Springer Verlag (1992).
4. Garrett Paul, The Mathematics of Coding Theory, Pearson Education (2004).

ADVANCED COMPLEX ANALYSIS (MMS-504)

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Unit-I

Analytic continuation, Analytic continuation by power series method, Natural boundary, Schwarz reflection principle, Analytic continuation along a path, Monodromy theorem, Runge's theorem, simple connectedness, Mittag-Leffler's theorem.

Unit-II

Maximum principle, Schwarz's Lemma, Hadamard's three circle theorem, Phragmen-Lindelof theorem, Weierstrass factorization theorem, Factorization of sine function, Gamma function.Entire functions, Jensen's formula, the genus and order of an entire function, Hadamard factorization theorem.

Unit-III

Harmonic functions, Basic properties, Harmonic functions on a disc, Subharmonic and Superharmonic functions, The Dirichlet problem, Green's function.

Unit-IV

Normal families of analytic functions, Montel's theorem, Hurwitz's theorem, Riemann mapping theorem, Univalent function, Distortion and Growth theorem for the class of normalized univalent functions, Covering theorem, starlike functions, convex functions, Subordination principle.

BOOKS RECOMMENDED

1. Z.Nihari, Conformal Mapping, Conformal Mapping, McGraw-Hill,1952.
2. J. B. Conway, Functions of One Complex Variable, Springer-Verlag,1973
3. T. W. Gamelin, Complex Analysis, Springer, 2004.
4. W.Tutschke and H.L.Vasudeva, An Introduction to Complex Analysis- Classical and Modern Approaches, Chapman & Hall/CRC, 2005
5. E.T. Copson, An Introduction to Theory of Functions of a Complex Variable.

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Advanced Operations Research (MMS-505)

Unit 1

Advanced Linear Programming: Revised simplex method, Sensitivity analysis, Parametric programming, Integer programming branch and bond algorithm, Goal programming, Standard form of LGPP, Partitioning algorithm.

Unit 2

Game Theory: Two person zero sum games pure strategies (minmax and maximum principles), Game with saddle point, Mixed strategies: Game without saddle point, Rule of Dominance, Solution methods for games without saddle point: Graphical method, Linear programming method.

Unit 3

Dynamic Programming: Characteristics of dynamic programming, Recursive relations, continuous and discrete cases, forward recursion, linear programming versus dynamic programming, Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.

Unit 4

Inventory Models: (a) Deterministic models: Classic EOQ (Economic order quantity) models, EOQ with price brakes, Multi item EOQ with storage limitation, Dynamic EOQ models(b) Probabilistic models: Probabilistic EOQ models, Single period models and multiperiod models.

Books Recommended

1. Taha, H.A., Operations Research- An introduction , PHI, 2007, Eighth ed.
2. Sharma, J.K, Operation research: Theory & Applications ,Macmillan India, 2007, Third ed
3..Kasana, H.S and Kumar K.D, Introductory Operations Research: Theory & Applications Springer, 2005
4. Pant, J.C, Introduction to Optimization and Operations Research, Jain Brothers, 2004

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Scheme and Syllabus of
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ADVANCED FLUID MECHANICS (MMS-506)

UNIT-I

Basic Concepts: Continuum Hypothesis, Viscosity, Most general motion of a fluid element, Rate of strain quadric, stress at a point, Tensor character of stress matrix, Symmetry of stress matrix, stress quadric, Stress in a fluid at rest, stress in a fluid in motion, Relation between stress and rate of strain components (Stoke's law of friction), Thermal conductivity, Generalized law of heat conduction,

Fundamental equations of the flow of viscous fluids: Equation of state, equation of continuity - Conservation of mass, Equation of motion- Navier-Stoke's equations, Equation of energy- Conservation of energy, Symmetry of fundamental equations, Vorticity and circulation in a viscous incompressible fluid motion, (a) velocity transport equation, (b) Circulation

UNIT-II

Dynamical similarity and Dynamical Analysis: Dynamical similarity, Reynold's law, Inspection analysis, Dimensional analysis, Buckingham π-theorem. Method of finding out the pi-products, Application of pi-theorem to viscous and compressible fluid. Physical importance of non-dimensional parameters. Reynolds number, Eckert Number, Froude Number, Mach Number, Pecklet Number, Grashoff Number, Prandtl Number, Brinkman Number, Nussel Number.

Exact Solution of Navier-Stoke's equations of motion- Flow between parallel plates (Velocity and temperature distributions), (i) Plane Couette flows (ii) Plane Poiseulle Flow and (iii) Generalized Couette flow.

UNIT-III

Flow in a circular pipe (Hagen Poiseuille flow) -Velocity and temperature distribution, Flow through tubes of uniform cross section in the form of circle, annulus, ellipse and equilateral triangle under constant pressure gradient. Flow between two concentric rotating cylinders (Couette flow) , Flow in convergent and divergent channels,

UNIT-IV

Steady incompressible flow with variable viscosity: Variable viscosity plane Couette flow and plane poiseulle flow.

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Unsteady incompressible flow with constant fluid properties: Flow due to a plane wall suddenly set in motion, Flow due to an oscillating plane wall, Starting flow in plane Couette motion, Starting flow in pipes, Plane coquette flow with transpiration cooling.

Books Recommended

1. Bansal,J L, Viscous Fluid Dynamics, OXFORD & IBH Publishing Company Pvt. Ltd., New Delhi, 1992.

2. Chorlton, F., Textbook of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985.

3. Schlichting, H., Boundary Layer Theory, McGraw Hill Book Company, New York, 1979.

4. Young ,A. D., Boundary Layers, AIAA Education Series, Washington DC, 1989.

5. Yuan, S.W., Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976

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Advanced Solid Mechanics(MMS-507)

Unit-I

Basics and Extension of Beams: Hooke's law, generalized Hooke's law, Elastic moduli and their relationship, strain-energy density function and its connection with Hooke's law, Saint-Venant's principle. Extension of beams: extension of beams by longitudinal forces, beam stretched by its own weight and bending of beams by terminal couples.

Unit-II

Torsion and flexure of beams: Torsion of a circular shaft, cylindrical bars, and elliptic cylinder. Stress function, conformal mapping, solution of torsion problem by conformal mapping. Flexure of beams by terminal loads, bending of rectangular beams.

Unit-III

Two-and Three-dimensional Problems: Plane deformation, plane stress, plane elastostatic problems, Airy's stress function, solution of the bi-harmonic equation, stress and displacement formulae basic problems of circular region: uniform pressure, uniform radial displacement and concentrated loads. Spherical shell under external and internal pressures.

Unit-IV

Thermoelastic problems and VariationalMethods: Thermal stresses in spherical bodies, two-dimensional thermoelastic problems. Variational methods: Theorems of potential energy, minimum complementary energy, work and reciprocity, Ritz method for one- and two-dimensional problems and Galerkin's method. Kantorovich and Trefftz methods. Application of Treffz method.

Books Recommended

1. Sokolnikoff, I S Mathematical Theory of Elasticity, (Ch3: 20,21,23,26,28;Ch4: 31-36,43-44,52,57;Ch:5: 66-71, 77(a,b,c);Ch6: 94,96,99-101; Ch 7: 107-109, 112-113, 115, 117-119) TMH New Delhi 1978.
2. Timoshenko.S. and Young D.H. – "Elements of strength of materials Vol. I and Vol. II"., T. Van Nostrand Co-Inc Princeton-N.J. 1990.

3. Love, A.E.H, A Treatise on the Mathematical theory of Elasticity, Cambridge University Press (4th Edition , Jan 2013).

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Number Theory and Cryptography(MMS-508)

Unit-I

Some Topics in Elementary Number Theory: Time estimates for doing arithmetic, Divisibility and the Euclidean algorithm, Congruence's, some applications to factoring.

Unit-II

Finite Fields and Quadratic Residues: Finite fields, Quadratic residues and reciprocity.

Unit-III

Cryptography: some simple cryptosystems, enciphering matrices.

Unit-IV

Public Key: The idea of public key cryptography, RSA, Discrete log. Elliptic Curves: Basic facts, Elliptic curve cryptosystems.

BOOKS RECOMMENDED:

1. Koblitz N., A Course in Number Theory and Cryptography, Graduate Texts in Mathematics, No.114, Springer-Verlag, New York/Berlin/Heidelberg, 1987.
2. Baker A., A Concise Introduction to the Theory of Numbers, Cambridge University Press, New York/Port Chester/Melbourne/ Sydney, 1990.
3. Parshin A.N. and Shafarevich I.R. (Eds.), Number Theory, Encyclopaedia of Mathe-matics Sciences, Vol. 49, Springer-Verlag, New York/Berlin/Heidelberg, 1995.
4. Stillwell J., Elements of Number Theory, Undergraduate Texts in Mathematics, Springer-Verlag, NewYork/Berlin/Heidelberg, 2003.
5. Tilborg H.C.A. van, An Introduction to Cryptography, Kluwer Academic Publishers, Boston/ Dordrecht/Lancaster, 1988.

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Theory of Linear Operators (MMS-509)

Unit I

Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators. Properties of resolvent and spectrum. Spectral mapping theorem for polynomials.

Unit II

Elementary theory banach algebra, Spectral radius of a bounded linear operator on a complex banach space.

Unit III

General properties of compact linear operators. Spectral properties of compact linear operators on normed spaces. Behaviours of compact linear operators with respect to solvability of operator equations. Fredholm type theorems. Fredholm alternative theorm. Fredholm alternative for integral equations.

Unit IV

Spectral properties of bounded self-adjoint linear operators on a complex Hibert space. Positive operators. Monotone Sequences theorem for bounded self-adjoint operators on a complex Hilbert space, Square roots of a positive operator.

Books Recommended

1. Kreyszig E., Introductory functional analysis with applications, Johan-Wiley & Sons, New York, 1978.

2. Halmos P.R., Introduction to Hilbert space and the theory of spectral multiplicity, 2nd Edn. Chelsea Pub., Co., N.Y. 1957.

3. Dunford N. and Schwartz,J.T. Linear operators-3 parts, Inter-science Wiley, New York, 1958-71.

4. Bachman G. andNarici,L., Functional analysis, Academic Press, New York, 1998.

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Advanced Numerical Methods(MMS-510)

Unit-I

Iterative Methods for Linear Systems: The classical iterative methods (Jacobi, Gauss-Seidel andSuccessive Over Relaxation (SOR) methods),Krylov subspace methods; Conjugategradient, Bi-conjugate-gradient (BiCG), BiCG stability methods, Preconditioning techniques, parallelimplementations.

Unit-II

Finite Difference Methods: Explicit and implicit schemes, consistency, stability andconvergence, Lax equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

Unit-III

Approximate methods of solution: Rayleigh-Ritz, collocation andGalerkin methods, properties ofGalerkin approximations, Petrov-Galerkin method, Generalized Galerkin method.

Unit-IV

Finite Element Method (FEM): FEM for second order problems, One and two dimensionalproblems, The finite elements (elements with a triangular mesh and a rectangular mesh and threedimensional finite elements), Fourth-order problems, Hermite families of elements,iso-parametric elements, numerical integration.

BOOKS RECOMMENDED:

1. Jain, M.K, Iyengar, S.R.K. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age international, 2008, 5th Edition.

2. Hoffman Joe D., Numerical methods for Engineers and Scientists, McGrow-Hill, 1993.

3. Atkinson, K.E, An Introduction to Numerical Analysis, John Wiley, 2004, 2nd Edition.

4. Gupta R.S., Elements of Numerical Analysis, McMillan India, 2009

5. Seshu P., Textbook of Finite Element Analysis, Prentice Hall India, 2003.

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Topological Vector Spaces (MMS-511)

Unit-I

Review of basic concepts of topological spaces and vector spaces. Prodect topological spaces, projection maps, compactness of prodect topological spaces-Tichonov's theorem.

Topological vector spaces (TVSs), examples of TVSs, Normed vector spaces as TVSs, Translation and multiplication maps, Neighbourhood of 0, separated TVS, linear maps between TVSs, Bounded subsets of a topological vector space.

Unit-II

Locally convex topological spaces, normable and metrizable topological vector spaces, complete topological vector spaces

Unit-III

Frechet spaces, Uniform boundedness principle, open mapping and closed graph theorems for Frechet spaces.

Unit-IV

Banach-Alaoglu theorem, Variational inequalities, Lion-Stampacchia theory, Physical phenomenon represented by variational inequalities, points and external sets-KreinMiliman theorem.

BOOKS RECOMMENDED:

1. Munkres J. R., Topology – A First Course, Prentice-Hall of India, 1978.

2. Kelley,J.L. Linear topological spaces, Van Nostrand East West Press, New Delhi.

3. Wilansky A., Modern Methods in Topological Vector Spaces, McGraw Hill, 1978.

4. Simmons G. F. – Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.

5. Rudin W., Functional Analysis, McGraw Hill,2nd edition , 1973.

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Fractional Calculus (MMS-512)

Unit-I

Special Functions of the Fractional Calculus. Gamma Function. Mittag-Leffler function, Fractional Derivatives and Integrals. Grunwald-Letnikov Fractional Derivatives. RiemannLiouville Fractional Derivatives. Some Other Approaches.

Unit-II

Geometric and PhysicalInterpretation of Fractional Integration and Fractional Differentiation. SequentialFractional Derivatives. Left and Right Fractional Derivatives. Properties of FractionalDerivatives. Laplace Transforms of Fractional Derivatives. Fourier Transforms ofFractional Derivatives. Mellin Transforms of Fractional Derivatives.

Unit-III

Linear Fractional Differential Equations. Fractional Differential Equation of a GeneralForm. Existence and Uniqueness Theorem as a Method of Solution. Dependence of aSolution on Initial Conditions. The Laplace Transform Method . Standard FractionalDifferential Equations. Sequential Fractional Differential Equations.Fractional Green's Function. Definition and Some Properties. One-Term Equation. TwoTerm Equation. Three-Term Equation. Four-Term Equation. General Case: n-termEquation.

Unit-IV

Other Methods for the Solution of Fractional-order Equations. The Mellin TransformMethod. Power Series Method. Babenko's Symbolic Calculus Method. Method ofOrthogonal Polynomials. Numerical Evaluation of Fractional Derivatives.Approximation of Fractional Derivatives. Order of Approximation.Computation of Coefficients. Higher-order Approximations.

Books Recommended

1. Podlubny, I.: Matrix approach to discrete fractional calculus. Fractional Calculus andApplied Analysis, vol. 3, no. 4, 2000.

2. Carpinteri A, Mainardi F, editors. Fractals and fractional calculus in continuummechanics. New York: Springer-VerlagWien; 1997.

3. Mandelbrot BB. The fractal geometry of nature. New York:W. H. Freeman; 2000.

4. Miller KS, Ross B. An introduction to the fractional calculus. New York:John Wiley;1993.

5. Oldham KB, Spanier J. The fractional calculus. New York: Academic Press; 1974.

Scheme and Syllabus of

M.Sc. Mathematics Batch 2017 onwards

M.Sc. Mathematics is a postgraduate level course of the Department of Mathematics which is a 2-years course. It is consisting of semester system (4 semesters) with two semesters per year.

Program Code: MSM (Masters of Science in Mathematics)

Eligibility: B.A./B.Sc. with Honors in Mathematics or B.A./B.Sc. (pass course) with Mathematics as one of the subjects having at least 50% marks in aggregate.

First Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM-101	Algebra-I	4	1	0	20	80	100	5
MSM -102	Real Analysis-I	4	1	0	20	80	100	5
MSM -103	Complex Analysis	4	1	0	20	80	100	5
MSM -104	Ordinary Differential Equations and Special Functions	4	1	0	20	80	100	5
MSM -105	Mathematical Methods	4	1	0	20	80	100	5
MSM -106	Introduction to Computer Algebra System (Lab)	0	0	2	50	00	50	1
Total		20	05	02	150	400	550	26

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Second Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM -201	Algebra-II	4	1	0	20	80	100	5
MSM -202	Real Analysis-II	4	1	0	20	80	100	5
MSM -203	Mechanics-I	4	1	0	20	80	100	5
MSM -204	Partial Differential Equations	4	1	0	20	80	100	5
MSM -205	Numerical Analysis	4	1	0	20	80	100	5
MSM -206	Numerical Analysis (Lab)	0	0	2	50	00	50	1
Total		20	05	02	150	400	550	26

Third Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM -301	Topology	4	1	0	20	80	100	5
MSM -302	Number Theory and Cryptography	4	1	0	20	80	100	5
MSM -303	Mathematical Statistics-I	4	1	0	20	80	100	5
MSM -304	Functional Analysis	4	1	0	20	80	100	5
MSM -XXX	Elective-I	4	1	0	20	80	100	5
MSM -305	Seminar	0	0	2	50	-	50	1
Total		20	05	02	150	400	550	26

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Fourth Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MSM -401	Mechanics-II	4	1	0	20	80	100	5
MSM -402	Mathematical Statistics-II	4	1	0	20	80	100	5
MSM-403	Differential Geometry	4	1	0	20	80	100	5
MSM -YYY	Elective-II	4	1	0	20	80	100	5
MSM -ZZZ	Elective-III	4	1	0	20	80	100	5
MSM -404	Seminar	0	0	2	50	-	50	1
Total		20	05	02	150	400	550	26

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Scheme and Syllabus of

M.Sc. Mathematics Batch 2017 onwards

Elective-I MSM XXX (Any one subject to be opted)

MSM -501 Coding Theory

MSM -502 Operations Research

Note1: Student is to adopt one course from the list of Elective-II and one course from list of Elective-III

Elective-II Courses: MSM-503, MSM-504, MSM-505, MSM-506

Elective-III Courses: MSM-507, MSM-508, MSM-509, MSM-510, MSM-511

MSM -503 Advanced Complex Analysis

MSM -504 Advanced Operations Research

MSM -505 Advanced Fluid Mechanics

MSM -506 Advanced Solid Mechanics

MSM -507 Theory of Linear Operators

MSM -508 Advanced Numerical Methods

MSM -509 Topological Vector Spaces

MSM -510 Fractional Calculus

MSM -511 Discrete Mathematics

Note 2:

Instructions for paper setters and candidates:

a) The entire question paper should be distributed into three sections viz. Section-A, Section-B, Section-C.
b) The Section-A should cover the entire syllabus, the Section-B should cover Unit-I & II and the Section-C should cover Unit-III & IV of the syllabus.
c) Section-A should contain eight questions of two marks each. This section should cover the entire syllabus. All questions in this section should be compulsory.
d) Section-B and Section-C should contain three questions each carrying 16 (sixteen) marks.
e) Student should be asked to attempt at least two questions from Section-B and Section-C each.
f) The awards for internal and external examination should be in 20:80 ratio.
g) The Duration of examination is three hours.

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Course Title: Algebra-I
Course Code: MSM-101

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Course Objectives: The main aim of the course:

- is to introduce basic topics of algebra like groups, sylow groups, rings, ideals, etc.
- to make the students learn about operations on algebraic structures which are quite significant in modern mathematics.
- to make the students understand the theorems of group isomorphisms and ring isomorphisms.

UNIT-I

Groups: Groups, homomorphisms, Subgroups and Cosets, Cyclic groups, Permutation groups, Normal subgroups and quotient groups, Isomorphism theorems, Automorphisms, Dihedral groups, Symmetric groups, Conjugacy. [Ref 2: Unit 1]

UNIT-II

Normal series, Derived Series, Composition Series, Solvable Groups, Simple groups and their examples, Alternating group A_n, Simplicity of A_n. [Ref 2: Unit 1]

UNIT-III

Direct Products, Finite Abelian Groups, Fundamental Theorem on Finitely generated Abelian Groups, Invariants of a finite abelian groups, Sylow's Theorems and their applications, Groups of order p^2, pq. [Ref 2: Unit 1]

UNIT-IV

Rings: Ring, Subring, Ideals, Homomorphism and Algebra of Ideals, Maximal and prime ideals, Ideals in quotient rings, Nilpotent and nil ideals. [Ref 2: Unit 2]

RECOMMENDED BOOKS:

1. Bhattacharya, P. B., Jain, S.K. and Nagpaul, S.R., *Basic Abstract Algebra, 2nd Edition.* U.K.: Cambridge University Press, 2004.
2. Dummit, David. S., and Foote, Richard M., *Abstract Algebra, 3rd Edition*. New Delhi: Wiley, 2011.
3. Herstein, I.N., *Topics in Algebra, 2nd Edition*. New Delhi: Wiley, 2006.
4. Singh, Surjeet, and Zameeruddin, Q., *Modern Algebra, 7th Edition*. New Delhi: Vikas Publishing House, 1993.
5. Artin, M., *Algebra, 2nd Edition*. Pearson Publications, 2010.
6. Fraleigh, J. B., *A First Course in Abstract Algebra, 7th Edition*. Pearson Publications, 2002.

Course Outcomes:

- The students will be able to learn the basic concepts like groups, rings, etc.

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- They will be acquainted with prerequisite knowledge required to learn advanced algebra.
- They will be able to apply the learnt techniques in modern algebra

Course Title: Real Analysis-I
Course Code: MSM-102

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Course Objectives: This course will develop

- a deeper and rigorous understanding of fundamental concepts viz. metric spaces, some important sets, continuous functions, sequences and series of numbers as well as functions, and the Riemann-Stieltjes integral in analysis.
- to introduce theoretical foundations of the above said concepts to students
- to develop their rigorous mathematical thinking and writing.

UNIT-I

Finite, Countable and Uncountable sets, Metric spaces, Compact sets, Perfect sets, Connected sets, Convergent sequences, Sub sequences, Cauchy sequences, Power series, Absolute convergence, Algebra of series, Rearrangements of elements in a series.

UNIT-II

Limits of functions, Continuous functions, Compactness, Connectedness, Monotonic functions, Infinite limits and Limits at infinity.

UNIT-III

The Riemann-Stieltjes integral: Definition and existence of the Riemann-Stieltjes integral, Properties of the integral, Integration and differentiation, Integration of vector-valued functions, Rectifiable curves.

UNIT-IV

Sequences and series of functions: Interchanging order of limits for sequences of functions, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, Stone Weierstrass Theorem.

RECOMMENDED BOOKS:

1. Rudin, W., *Principles of Mathematical Analysis, 3rd Edition*. New Delhi: McGraw-Hill Inc., 2013.
2. Royden, H.L. and Fitzpatrick, P.M., *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.
3. Carothers, N. L., *Real Analysis*, Cambridge University Press, 2000.
4. Apostol, T.M., *Mathematical Analysis –A modern approach to Advanced Calculus*. New Delhi: Narosa Publishing House, 1957.
5. Abbott, S., *Understanding Analysis, 2nd Edition.* Springer, 2016.

Course Outcomes: After completion of the course, the student will be able to

- Understand hypotheses and writing mathematical proofs.

- Understand the theoretical structures of basic concepts in analysis.
- Understand axiomatic structure of metric spaces and consideration of sequences and series, continuous functions in metric spaces.
- Understand the theoretical foundation and properties of the Riemann-Stieltjes integral.

Course Title: Complex Analysis
Course Code: MSM-103

L	T	P
4	1	0

Course Objectives: The objective of this course is

- to introduce and developing a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions etc.
- to make students equipped with the understanding of the fundamental concepts of complex variable theory.
- in particular, to enable students to acquire skill of contour integration to evaluate complicated real integrals via residue calculus.

UNIT-I

Function of complex variable, continuity and differentiability, Analytic functions, Cauchy Riemann equation (Cartesian and polar form). Harmonic functions, Harmonic conjugate, Construction of analytic functions. Exponential function, Trigonometric and inverse trigonometric functions, Logarithmic function, Complex powers, Branches of multivalued functions with reference to arg(z), log(z), z^c. Stereographic projection and the spherical representation of the extended complex plane.

Unit-II

Complex line integral, Cauchy-Goursat theorem, independence of path; Cauchy's integral formulas and their consequences, Cauchy inequality, Liouville's theorem, Fundamental theorem of algebra, Morera's theorem, Maximum modulus principle, Schwarz lemma, Poisson's integral formula.

Unit-III

Power series: circle of convergence, radius of convergence. Taylor's series and Taylor's theorem, Laurent'z series and Laurent theorem, Zeros and singularities of complex functions, classification of singularities: removable singularity, poles, essential singularities, Residue at a pole and at infinity, Cauchy's Residue theorem and its applications in evaluation of real integrals: integration around unit circle, integration over semi-circular contours (with and without real poles), integration around rectangular contours, Argument principle, Rouche's theorem

Unit-IV

Conformal transformations, Bilinear transformations, Critical points, Fixed points, Problems on cross-ratio and bilinear transformation.

RECOMMENDED BOOKS:

1. Ahlfors, L.V., *Complex Analysis, 2nd Edition*. McGraw-Hill International Student Edition, 1990.
2. Copson, E.T., *An Introduction to the Theory of functions of a complex Variable*. Oxford university press, 1995.
3. Shastri, A.R., *An Introduction to Complex Analysis*. Macmillan India Ltd., 2003.
4. Ponnusamy, S. and Silverman, H., *Complex Variables and Applications*. Birhkäuser, 2006.

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5. Churchill, R. and Brown, J.W., *Complex Variables and Applications*, *6th Edition*. New- York: McGraw-Hill, 1996.

Course Outcomes: After the completion of this course the student will be able to

- represent complex numbers algebraically and geometrically.
- Evaluate Complex integrals and applying Cauchy integral.
- evaluate limits and checking the continuity of complex function & 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.

Course Title: Ordinary Differential Equations and Special Functions
Course Code: MSM-104

L	T	P
4	1	0

Course Objectives: The objective of this course is

- to introduce ordinary differential equations and fundamental theorems for existence and uniqueness.
- to learn analytic techniques for computing solutions of various ordinary differential equations with and without initial and boundary conditions.
- to explore the use of series methods about ordinary and regular-singular points.

UNIT-I

Review of linear differential equations with constant & variable coefficients, Fundamental existence and uniqueness theorem for system and higher order equations (Picard's and Piano theorems), System of linear differential equations, an operator method for linear system with constant coefficients, Phase plane method.

UNIT-II

Homogeneous linear system with constant coefficients, Eigenvalues and eigen functions, orthogonality of eigen functions, Complex eigenvalues, repeated eigenvalues, Ordinary differential equations of the Sturm-Liouville problems, Expansion theorem, Extrema properties of the eigen values of linear differential operators, Formulation of the eigen value problem of a differential operator as a problem of integral equation, Linear homogeneous boundary value problems

UNIT-III

Power series solution of differential equations: about an ordinary point, solution about regular singular points, the method of Frobenius, Bessel equation and Bessel functions, Recurrence relations and orthogonal properties., Series expansion of Bessel Coefficients, Integral expression, Integral involving Bessel functions, Modified Bessel function, Ber and Bei functions, Asymptotic expansion of Bessel Functions, Legendre's differential equations, Legendre Polynomials , Rodrigue's formula, Recurrence relations and orthogonal properties.

UNIT-IV

The Hermite polynomials, Chebyshev's polynomial, Laugrre's polynomial: Recurrence relations, generating functions and orthogonal properties.

RECOMMENDED BOOKS:

1. Ross, S.L., *Differential Equations, 3rd Edition*. John Wiley & Sons, 2004.
2. Boyce, W.E. and Diprima, R.C., *Elementary Differential Equations and Boundary Value problems, 4th Edition*. John Wiley and Sons, 1986.

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3. Sneddon, I.N., *Special Functions of Mathematical Physics and Chemistry*. Edinburg: Oliver & Boyd, 1956.
4. Bell, W.W., *Special Functions for Scientists and Engineers*. Dover, 1986.

Course Objectives: Students will be able to:

- classify ordinary differential equations according to their order and linearity, as well as distinguish between initial value problems and boundary value problems.
- determine regions of the plane in which a given first-order differential equation will have a unique solution.
- obtain solutions for system of ordinary differential equations and eigen value problems by using various tools of linear algebra.

Course Title: Mathematical Methods
Course Code: MSM-105

L	T	P
4	1	0

UNIT I

Laplace Transforms: Laplace Transform, Properties of Laplace Transform, Inverse Laplace Transform, Convolution theorem, Laplace transform of periodic functions, unit step function and impulsive function, Application of Laplace Transform in solving ordinary and partial differential equations and Simultaneous linear equations;

UNIT II

Fourier Transforms: Fourier transform, properties of Fourier transform, inversion formula, convolution, Parseval's equality, Fourier transform of generalized functions, application of Fourier transforms in solving heat, wave and Laplace equation. Fast Fourier transform.

UNIT III

Integral Equations: Relations between differential and integral equations, Green's function, Linear equations in cause and effect, Integral equations of Fredholm and Volterra type, solution by successive substitution and successive approximation, integral equations with degenerate kernels.

UNIT IV

Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems, integral equations with symmetric kernel, Solutions with separable kernels, Characteristic numbers, Resolvent kernel, Eigen values and Eigen functions of integral equations and their simple properties.

RECOMMENDED BOOKS:

1. Sneddon, I.N., *The Use of Integral Transforms*. McGraw Hill, 1985.
2. Goldberg, R.R., *Fourier Transforms*. Cambridge University Press, 1970.
3. Smith, M.G., *Laplace Transform Theory*. Van Nostrand Inc., 2000.
4. Elsegolc, L., *Calculus of Variation*. Dover Publications, 2010.
5. Kenwal, R.P., *Linear Integral Equation; Theory and Techniques*. Academic Press, 1971.
6. Hildebrand, F.B., *Methods of Applied Mathematics* ***(Latest Reprint)***. Dover Publications.

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7. Pal, S. and Bhunia, S.C., *Engineering Mathematics*. Oxford University Press, 2015.

Course Title: Introduction to Computer Algebra System
Course Code: MSM-106

L	T	P
0	0	2

Course Objectives: This course

- introduces computer algebra systems (CAS) viz. MATLAB and MATHEMATICA that are widely used in scientific computing.
- enables the students to be familiar with the CAS so that they can apply these systems to solve real world problems more efficiently and accurately.

UNIT-I

The MATLAB environment, scalars, variables, arrays, mathematical operations with arrays, built-in and user defined functions, graphics: two-dimensional and three-dimensional, m-files: script and function files, functions: input; disp and fprintf, relational and logical operators, symbolic math: symbolic objects and expressions; collect; expand; factor; simplify; simple; pretty; solve; diff and int commands, Programming: if-end structure; if-else-end structure; if-elseif-else-end structure; loops: for-end and while-end.

UNIT-II

The structure of MATHEMATICA, notebook interfaces, constants, variables, algebraic calculations, four kinds of brackets, lists, tables, expressions, functions, built-in functions, functional operations, graphics, patterns, manipulating lists, transformation rules, evaluation of expressions, modularity, manipulating notebooks, relational and logical operators, symbolic math commands: D; Integrate; Sum; Product; Solve; Eliminate; Reduce; Series; Limit; Minimize; basic numerical mathematics, Programming: conditionals; loops: Do; For and While.

RECOMMENDED BOOKS:

1. Higham, D.J. and Higham, N.J., *MATLAB Guide, 2nd Edition.* Society for Industrial and Applied Mathematics (SIAM), 2005.
2. Gilat, A., *MATLAB: An Introduction with Applications, 5th Edition*. John Wiley & Sons, 2014.
3. Wolfram, S., *The MATHEMATICA Book, 5th revised edition*. Wolfram Media Inc, 2004.
4. Abell, M. and Braselton, J., *Mathematica by Example, 5th Edition*. Academic Press, 2017.

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

- use symbolic tools of MATLAB and MATHEMATICA for doing mathematics more efficiently and rapidly.
- understand basic loops and conditional structures that can be used to develop their own computer programs.
- visualize functions in 2-D and 3-D.
- use these CAS for solving applied problems in science and engineering.

Course Title: Algebra-II
Course Code: MSM-201

L	T	P
4	1	0

Course Objectives: The main aim of this course

- is to introduce the students to advanced ideas such as Polynomial rings, Field theory, Algebraic closures, splitting fields and Galois theory.
- To make the students learn about Eisenstein's irreducibility criterion which is quite helpful in the study of solvability of a polynomial.
- To make the students understand about the applications of Galois theory in other branches of mathematics.

UNIT-I

Polynomial rings, factorization of polynomials in one variable over a field. Unique factorization domains, unique factorization in R[x], where R is a Unique Factorization Domain. Euclidean and Principal ideal domain. [Ref 2: Unit 2]

UNIT-II

Gauss Lemma, irreducible polynomials and Eisenstein's Irreducibility Criterion, Fields, Adjunction of roots, Algebraic extensions of field. [Ref 2: Unit 2,4]

UNIT-III

Algebraically closed fields, Splitting fields, normal extensions, finite fields, separable extensions. [Ref 2: Unit 4]

UNIT-IV

Automorphism of groups and fixed fields, Galois extensions. The fundamental theorem of Galois Theory, Fundamental theorem of algebra. [Ref 2: Unit 4]

RECOMMENDED BOOKS:

1. Bhattacharya, P.B., Jain, S.K. and Nagpaul, S.R., *Basic Abstract Algebra, 2nd Edition.* U. K.: Cambridge University Press, 2004.
2. Dummit, David. S., and Foote, Richard M., *Abstract Algebra, 3rd Edition*. New Delhi: Wiley, 2011.
3. Herstein, I.N., *Topics in Algebra, 2nd Edition*. New Delhi: Wiley, 2006.
4. Singh, Surjeet, and Q. Zameeruddin. *Modern Algebra, 7th Edition*. New Delhi: Vikas Publishing House, 1993.
5. Ash, R., *Abstract Algebra: The Basic Graduate Year*, Dover Publications Inc, 2006.

Course Outcomes:

• The students will be able to learn the advanced concepts of algebra which will develop their interest to pursuit study in advanced algebra.

• They will acquire abstract and rational thinking by understanding the concepts such as Eisenstein's irreducibility criterion.

• They will be encouraged to do further research in advanced algebra.

Course Title: Real Analysis-II
Course Code: MSM-202

L	T	P
4	1	0

Course Objectives: This course aims

- to lay theoretical foundations of important aspects of mathematical analysis viz. derivative, mean value theorems (MVTs), functions of several variables, measure theory and integration that have many important applications in different branches of pure and applied mathematics.
- to make students familiar with these concepts, their properties and also some of their fruitful applications.

UNIT-I

Differentiation of Real functions, Mean value theorems, Taylor's theorem, Differentiation of vector-valued functions, Functions of several variables: **Linear transformations, Differentiation, Contraction principle, The Inverse function theorem, The implicit function theorem. [Ref. 3]**

UNIT-II

Lebesgue Measure: Introduction, Lebesgue outer measure, Measurable sets and Lebesgue measure, non-measurable set, Measurable functions, Borel and Lebesgue measurability, Littlewood's three principles.

UNIT-III

Lebesgue Integral: The Riemann integral, The Lebesgue integral of a bounded function over a set of finite measure, the integral of a nonnegative function, The general Lebesgue integral, Convergence in measure.

UNIT-IV

Differentiation and Integration: Differentiation of monotone functions, The Four derivatives, Functions of bounded variation, differentiation of an integral, Lebesgue Differentiation Theorem. Absolute continuity. Convex Functions.

RECOMMENDED BOOKS:

1. Royden, H.L. and Fitzpatrick, P.M., *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.
2. Barra, G. de., *Measure Theory and Integration*, New Delhi: Woodhead Publishing, 2011.
3. Rudin, W., *Principles of Mathematical Analysis, 3rd Edition*. New Delhi: McGraw-Hill Inc., 2013.
4. Carothers, N. L., *Real Analysis*, Cambridge University Press, 2000.
5. Apostol, T.M., *Mathematical Analysis –A modern approach to Advanced Calculus*. New Delhi: Narosa Publishing House, 1957.

Course Outcomes After completing the course, the student will

- understand derivative, MVTs and functions of several variables that would be the basis for rigorous understanding of advanced analysis and its applications.
- understand how Lebesgue measure is defined and its properties.
- understand how the measures may be used in the development of integrals.
- become familiar with deep understanding and application of Lebesgue theory of integration.

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Course Title: Mechanics-I
Course Code: MSM-203

L	T	P
4	1	0

UNIT-I

Functional and its properties, Variation of a functional, Motivating problems: Brachistochrone, isoperimetric, Geodesics. Fundamental lemma of calculus of variation, Euler's equation for one dependent function of one and several variables. Generalization to n dependent functions and dependence on several derivatives. Invariance of Euler's equation, Moving end points problem, extremum under constraints.

UNIT-II

Constraints, Generalized coordinates, Generalized velocity, Generalized force, Generalized potential, D'Alembert principle, Lagrange's equation of first kind and second kind, uniqueness of solution, Energy equation for conservative field. Examples based on solving Lagrange's equation.

UNIT-III

Legendre transformation, Hamilton canonical equation, cyclic coordinates, Routhian procedure, Poisson bracket, Poisson's identity, Jacobi-Poisson theorem, Hamilton's principle, Principle of Least action, Small oscillations of conservative system, Lagrange's equation for small oscillations, Nature of roots of frequency equation, Principle oscillations. Normal coordinates.

UNIT-IV

Canonical transformations, Hamilton-Jacobi equation. Method of Separation of variables, Lagrange's bracket, Hamilton's equations in Poisson bracket, Canonical character of transformation through Poisson bracket. Invariance of Lagrange's bracket and Poisson's bracket. Action-Angle Variables.

RECOMMENDED BOOKS:

1. Elsegolc, L.D., *Calculus of Variation*, Dover Publication, 2007.
2. Gantmacher, F., *Lectures in Analytic Mechanics,* Moscow: Mir Publisher, 1975.
3. Goldstien, H., Poole, C. and Safco, J.L., *Classical Mechanics, 3rd Edition*. Addison Wesely, 2002.
4. Landau, L.D. and Lipshitz, E.M., *Mechanics,* Oxford: Pergamon Press, 1976.
5. Marsden, J.E., *Lectures on Mechanics*, Cambridge University Press, 1992.
6. Biswas, S. N., *Classical Mechanics*, Books and Applied (P) Ltd., 1999.

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Course Title: Partial Differential Equations
Course Code: MSM-204

L	T	P
4	1	0

Course Objectives: the objective of this course is

- to introduce first and higher order partial differential equations and their classification
- to study analytic methods for computing solutions of various partial differential equations.
- to study applications of partial differential equations which appear in real life and physical phenomena like as wave equation of string, diffusion equation and heat flow equation etc.

UNIT-I

First Order PDE: Partial differential equations; its order and degree; origin of first-order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution.

UNIT-II

Second and Higher Order PDE: Origin of second order PDE; linear second and higher order PDE with constant and variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order.

UNIT-III

Separation of Variable Method: Separation of variables for PDE; wave, diffusion and Laplace equations and their solutions by Separation of variables method; Elementary solutions of Laplace equations.

UNIT-IV

Applications of PDE: Vibrations governed by one and two-dimensional wave equations; vibrations of string and membranes; three dimensional problems; diffusion equation; resolution of boundary value problems for diffusion equations and elementary solutions of diffusion equations.

RECOMMENDED BOOKS:

1. Sneddon, I.N., *Elements of Partial Differential Equation, 3rd Edition.* McGraw Hill Book Company, 1998.
2. Copson, E.T., *Partial Differential Equations, 2nd Edition.* Cambridge University Press, 1995.
3. Strauss, W.A., *Partial Differential Equations: An Introduction, 2nd Edition.* 2007.
4. Sharma, J.N. and Singh, K., *Partial differential equations for engineers and scientists, 2nd Edition.* New Delhi: Narosa Publication House, 2009.

Course Outcomes: Students will be able to:

- understand the mathematical derivation of the methods and partial differential equations.
- learn analytic techniques for computing solutions of various partial differential equations.
- learn the behavior of partial differential equations as parabolic, elliptic and hyperbolic and the applications of partial differential equations.

Course Title: Numerical Analysis
Course Code: MSM-205

L	T	P
4	1	0

Course Objectives: The objective of this course includes

- the study the basic numerical methods and their convergence properties for solving nonlinear equations, linear system of equations, initial value problems and boundary value problems.
- the study of numerical methods for differentiation, integration, including Romberg integration.
- the course will also develop an understanding of the elements of error analysis for numerical methods.

UNIT-I

Numerical computation and Error analysis: Numbers and their accuracy, Floating point arithmetic, Errors in numbers, Error estimation, General error formulae, Error propagation in computation. Inverse problem of error analysis and Numerical instability. Algebraic and transcendental equations: Bisection method, Iteration method, Regula-Falsi method, Secant method, Newton-Raphson's method. Convergence of these methods. Lin-Bairstow's method, Muller's method, Graeffe's root squaring method, Solution of system of nonlinear equations, Complex roots by Newton-Raphson's method.

UNIT-II

System of linear algebraic equations: Gauss elimination method without pivoting and with pivoting, Gauss-Jordon method, LU-factorization method, Jacobi and Gauss-Seidal methods, Convergence of iteration methods, Round-off errors and refinement, ill-conditioning, Partitioning method, Inverse of matrices. Eigen values and eigen vectors: Rayleigh Power method, Given's method and Householder's method.

UNIT-III

Interpolation: Finite differences, Newton's interpolation formulae, Gauss, Stirling's and Bessel's formulae, Lagrange's, Hermite's and Newton's divided difference formulae. Numerical differentiation and integration: differentiation at tabulated and non-tabulated points, Maximum and minimum values of tabulated function, Newton-Cotes Formulae-Trapezoidal, Simpson's, Boole's and Weddle' rules of integration with errors, Romberg integration, Gaussian integration, Double integration by Trapezoidal and Simpson's rules.

UNIT-IV

Ordinary differential equations: Taylor series and Picard's methods, Euler's and modified Euler methods, Runge-Kutta methods, Predictor-Corrector methods: Adams-Bashforth's and Milne's methods. Error analysis and accuracy of these methods. Solution of simultaneous and higher order equations, Boundary value problems: Finite difference and Shooting methods.

RECOMMENDED BOOKS:

1. Sharma, J.N., *Numerical Methods for Engineers and Scientists, 2nd Edition*. Narosa Publ. House New Delhi/Alpha Science International Ltd., Oxford UK, 2007, Reprint 2010.
2. Jain, M.K., Iyengar, S.R.K. and Jain, R.K., *Numerical Methods for Scientific and Engineering Computation, 5th Edition. New Age International Publ.* New Delhi, 2010
3. Bradie, B., *A Friendly Introduction to Numerical Analysis*. Pearson Prentice Hall, 2006.
4. Atkinson, K.E., *Introduction to Numerical Analysis, 2nd Edition*. John Wiley, 1989.
5. Scarborough, J.B., *Numerical Mathematical Analysis*. Oxford & IBH Publishing Co., 2001.

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

- apply the numerical methods (such as Bisection, False position, Newton-Raphson, Secant, to solve equations.
- apply the numerical methods (such as Gauss Elimination, Gauss Jordan, LU factorization, Cholesky Factorization, Jacobi and Gauss Seidel) for linear system of equations.
- apply the numerical methods (such as Newton forward and backward difference interpolation formula- Lagrange interpolation formula) for differentiation and integration.

Course Title: Numerical Analysis (LAB)
Course Code: MSM-206

L	T	P
0	0	2

Course Objectives: This course

- provides understanding of implementations of basic numerical methods for solving problems viz. nonlinear equations, system of equations, interpolation, extrapolation, differentiation, integration and ordinary differential equations.
- to enable students to develop their own computer programs of the numerical methods for solving different problems.

The following programs of following methods are to be practiced:

1. To find a real root of an algebraic/ transcendental equation by using Bisection method.
2. To find a real root of an algebraic/ transcendental equation by using Regula-Falsi method.
3. To find a real root of an algebraic/ transcendental equation by using Newton-Raphson method.
4. To find a real root of an algebraic/ transcendental equation by using Iteration method.
5. Implementation of Gauss- Elimination method to solve a system of linear algebraic equations.
6. Implementation of Jacobi's method to solve a system of linear algebraic equations.
7. Implementation of Gauss-Seidel method to solve a system of linear algebraic equations.
8. To find differential coefficients of 1st and 2nd orders using interpolation formulae.
9. To evaluate definite integrals by using Newton - Cotes integral formulae.
10. To evaluate definite integrals by using Gaussian Quadrature.
11. To evaluate double integrals by using Trapezoidal and Simpson method.
12. To compute the solution of ordinary differential equations with Taylor's series method.
13. To compute the solution of ordinary differential equations by using Euler's method.
14. To compute the solution of ordinary differential equations by using Runge -Kutta methods.
15. To compute the solution of ordinary differential equations by using Milne-Simpson method.
16. To compute the solution of Boundary value problems of Ordinary Differential Equations by using Finite Difference method.
17. To compute the solution of Boundary value problems of Ordinary Differential Equations by using Shooting method.

RECOMMENDED BOOKS:

1. Fausett, L.V., *Applied Numerical Analysis using MATLAB, 2nd Edition.* Pearson Prentice Hall, 2007.
2. Mathews, J.H. and Fink, K.D., *Numerical Methods using MATLAB, 4th Edition.* Pearson Prentice Hall, 2004.
3. Balagurusamy, E., Object Oriented Programming with C++. New Delhi: Tata McGraw Hill, 1999.
4. Conte, S.D. and Boor, C.D., *Numerical Analysis*. New York: McGraw Hill, 1990.

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

- Understand different implementation modes of numerical methods.
- Develop and implement their own computer programs.
- Solve problems more accurately and efficiently.

Instructions for paper setters and candidates:
Candidates are required to perform at least 10-12 Practical in a semester.

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Course Title: Topology
Course Code: MSM-301

L	T	P
4	1	0

UNIT-I

Introduction topological spaces, closed sets, Closure, Dense subsets, neighborhoods, interior, exterior and boundary, Accumulation points and derived sets.
Bases and subbases, Subspaces and relative Topology, Alternative methods of defining a Topology in terms of Kuratowski closure operator and neighborhood systems.

UNIT-II

Open mappings and closed mappings, Continues functions and homomorphism's, Compactness and local Compactness. One-point compactification, connected and arc-wise connected spaces, Components and Locally connected spaces.

UNIT-III

T0 and T1 spaces, T2 spaces and sequences. Hausdorffness of one-point compactification, Axioms of Countability and Seperability, Equivalence of Separable, second Axiom and Lindel of properties in a metricspaces. Equivalence of compact and countably compact sets in metric spaces.

UNIT-IV

Regular and completely regular, Normal and completely normal spaces. Metric spaces as T2, completely normal and first axiom spaces, Urysohn's Lemma, Tietze Extension Theorem.

BOOKS RECOMMENDED

1. Munkres, J. R., *Topology, a first course*, Prentice-Hall of India Ltd., New Delhi, 2000.
2. Joshi, K. D., *An introduction to general topology, 2nd edition,* Wiley Eastern Ltd., New Delhi, 2002.
3. Simmons, G.F., *Introduction to topology and Modern Analysis*, McGraw Hill Publications, 2017.
4. Kelley, J. L., *General Topology*, Springer Verlag, New York, 1990.
5. Armstrong, M.A., *Basic Topology*, Springer International Ed., 2005.

Course Title: Number Theory and Cryptography
Course Code: MSM-302

L	T	P
4	1	0

Course Objectives: The main objectives of this course:

- is to teach the basic foundations of Number Theory, namely, Prime Numbers, Division algorithm, Arithmetic functions, Diophantine equations and Cryptography.
- To make the students learn about the interrelation of various concepts of number theory such as Fermat's Last theorem, Reciprocity law, etc. with other branches of mathematics.

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- To make students understand the various techniques such as Division tests, Chinese remainder theorem, etc.
- To make the students learn about coding and decoding processes using Discrete log, public key cryptography and RSA cryptography.

UNIT-I

Divisibility, Greatest common divisor, Euclidean Algorithm, The Fundamental Theorem of arithmetic, congruences, Special divisibility tests, Chinese remainder theorem, residue classes and reduced residue classes, Fermat's little theorem, Wilson's theorem, Euler's theorem.

UNIT-II

Arithmetic functions $\phi(n)$, $d(n)$, $\sigma(n)$, $\mu(n)$, Mobius inversion Formula, the greatest integer function, perfect numbers, Mersenne primes and Fermat numbers,

UNIT-III

Primitive roots and indices, Quadratic residues, Legendre symbol, Gauss's Lemma, Quadratic reciprocity law, Jacobi symbol, Diophantine equations: $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$, sums of two and four squares, [Ref. 2]

UNIT-IV

Cryptography: some simple cryptosystems, need of the cryptosystems, Discrete log, the idea of public key cryptography, RSA cryptosystem. [Ref. 4]

RECOMMENDED BOOKS:

1. Burton, D.M., *Elementary Number Theory, 7th Edition*. McGraw-Hill Education, 2010.
2. Hardy, G.H. and Wright, E.M., *An introduction to the Theory of Numbers, 4th Edition*. Oxford University Press, 1975.
3. Niven, I., Zuckerman, H.S. and Montgomery, H.L., *Introduction to Theory of Numbers, 5th Edition*. John Wiley & Sons, 1991.
4. Koblitz N., *A Course in Number Theory and Cryptography, Graduate Texts in Mathematics, No.114*. New-York: Springer-Verlag, 1987.
5. Stallings, W., *Cryptography and Network Security, 5th Edition*. Pearson, 2010.

Course Outcomes:

- The students will learn fundamental theorems and results in number theory.
- They will be able to apply the learnt techniques in different fields of mathematics.
- They will be acquainted with prerequisite knowledge required to learn advanced course in Number Theory.
- They will be able to construct codes and decode the encrypted code using the learnt techniques.

Course Title: Mathematical Statistics-I
Course Code: MSM-303

L	T	P
4	1	0

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Course Objectives: The main objectives of this course is:

- To cover the basic concepts of mathematical statistics, random experiments and their applications.
- To make the students to learn the theory of probability, one dimensional and two-dimensional random variables, expectation etc. to study the random experiments.
- To enhance the statistical thinking of the students.

UNIT-I

Classical, empirical and axiomatic approaches to the theory of probability, the probability set function, algebra of events, conditional probability, addition and multiplicative theorems of probability and their generalizations to n events. Total probability theorem and Bayes' theorem and their applications.

UNIT-II

Random variables (discrete and continuous) and their density functions. Cumulative distribution function and its properties. Different methods to derive the distribution of the function of a random variable. Non-central and central moments of a random variable, expected value of functions of random variable.

UNIT-III

Two dimensional random variables, joint, marginal and conditional density functions, distribution function, independence of random variables. Distribution of the functions of two-dimensional random variables. Joint moments of a two-dimensional random variable.

Unit -IV

Cauchy-Schwartz inequality, Jenson's inequality, product moment correlation coefficient, conditional expectation and variance, probability generating function, moment generating function and its properties. Characteristic function and its elementary properties. Chebychev's inequality, Convergence in probability, weak law of large numbers.

BOOKS RECOMMENDED:

1. Hogg R. V., McKean J. W. and Craig A. T., Introduction to Mathematical Statistics, Pearson, 2005, Sixth Edition.
2. Gupta S. C. and Kapoor V. K., Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 2014, Eleventh Edition.
3. Fisz M., Probability Theory and Mathematical Statistics, John Wiley & Sons, 1967, Third Edition.
4. Gun A. M., Gupta M. K. and Dasgupta B., Fundamentals of Statistics (Vol-I), World Press, 2013.
5. Feller W., An Introduction to Probability Theory and Its Applications (Vol-I), John Wiley & Sons, 2003, Third Edition.
6.

Course Outcomes After completion of this course, the students will

- Learn the basic concepts of mathematical statistics.
- Be able to apply statistical methods in solving real life problems.
- Be able to analyze the different possible inferences for a given physical situation.

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Course Title: Functional Analysis
Course Code: MSM-304

L	T	P
4	1	0

UNIT-I

Normed linear spaces, Banach spaces, properties of normed spaces, finite dimensional normed spaces and subspaces, linear operators, bounded and continuous linear operators, linear functionals, normed spaces of operators

UNIT-II

Equivalent norms, conjugate spaces, Reflexivity. Hahn-Banach theorems for real/complex vector spaces and normed spaces, Applications to bounded linear functionals on C [a,b].

UNIT-III

Uniform boundedness theorem, open mapping theorem, closed graph theorem, Projections on Banach spaces.

UNIT-IV

Inner product spaces, Hilbert spaces, properties of inner product spaces, orthogonal complements, orthonormal sets, Hilbert – adjoint operator, self-ad joint, unitary and normal operators, projections on Hilbert spaces.

RECOMMENDED BOOKS:

1. Simmons, G.F., *Introduction to Topology and Modern Analysis*, 2008.
2. Rudin, W., *Functional Analysis, International Series in Pure and Applied Mathematics*, McGraw-Hill inc.,1991.
3. Kreyszig, E., *Introductory Functional Analysis with Applications*, John Wiley and Sons(Asia) Pvt. Ltd., 2006.
4. Bachman, G. and Narici, L., *Functional Analysis*, Dover, 2000.
5. Conway, J.B., *A Course in Functional Analysis, 2nd Edition*. Springer-Verlag, 2006.

Course Title: Mechanics-II
Course Code: MSM-401

L	T	P
4	1	0

Unit I

Tensors: Introduction, Range and Summation Conventions, Free and dummy suffixes, results in vector algebra and matrix, the symbol δ_{ij} & ε_{ijk} , Coordinate transformations, cartesian tensors, Properties of tensors, Isotropic tensors, Isotropic tensor of order four, Tensors as linear operators, Transpose of a tensor.

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Unit II

Tensor Continued: Symmetric and skew tensors, Dual vector of a skew tensor, Invariants of a tensor, Deviatoric tensors, Eigenvalues and eigenvectors, Polar decomposition, Scalar, vector and tensor functions, Comma notation, Gradient of a scalar, divergence and curl of a vector, Gradient of a vector, divergence and curl of a tensor, Integral theorems for vectors and tensors.

Unit III

Continuum Hypothesis: Notation of a continuum, Configuration of a continuum, Mass and density, Descriptions of motion, Deformation: Material and special coordinates, Deformation gradient tensor, Stretch and rotation, Strain tensors, Strain-displacement relations, Infinitesimal strain tensor, Infinitesimal stretch and rotation, Compatibility conditions., Principal strains, Strain-deviator.

Unit IV

Motion and Stress: Material and local time-derivatives, Stretching and vorticity, path lines, stream lines, and vortex lines, Transport formulas, Circulation and vorticity, Body forces and surfaces forces, Stress components, Stress tensor, Normal and shear stresses, stress-deviator, Boundary conditions for stress tensor, Piola-Kirchhoff stress tensors.

BOOKS RECOMMENDED:

1. Jog, C.S., *Foundations and Applications of Mechanics: Volume-I Continuum Mechanics.* Narosa Publishing House, New delhi.
2. Chandrasekharaiah, D.S. and Lokenath, D., *Continuum Mechanics,* Academic Press, London (Prism Books Pvt. Ltd., Bangalore-India).

Course Title: Mathematical Statistics-II
Course Code: MSM-402

L	T	P
4	1	0

Course Objectives: The main objectives of this course are:

- To introduce various types of distributions, descriptive statistics, theory of estimation and testing of hypothesis etc.
- To make the students learn estimation and testing of hypotheses of parameters of distributions and their applications in real life situations.

Unit-I

Study of various discrete and continuous distributions: Binomial, Poisson, Geometric, Hyper geometric, Multinomial; Uniform, Exponential, Normal, Cauchy, exponential, Beta and gamma distributions, Bivariate normal distribution. Convergence in distribution (law), Central limit theorems (Laplace-Demoiver and Lindeber-Levy).

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Unit-II

Introduction to statistical methods, frequency distributions, measures of central tendency and dispersion, moments and measures of Skewness and Kurtosis. Fitting of Binomial, Poisson and Normal distributions. Theory of attributes independence and association, bivariate correlation and regression.

Unit-III

General concept of Point estimation, unbiasedness, consistency, efficiency, sufficient statistics, Factorization Theorem (without proof), Cramer Rao Inequality (without proof) and their applications. Maximum Likelihood method of estimation and method of moments.

Unit-IV

Concept of sampling distribution and its standard error. Derivation of sampling distributions of Chi-square, t and F. Distribution of sample mean and sample variance from normal distribution. Test of significance, Type I and Type II errors, level of significance. Tests of significance using Chi-square, t and F distributions. Analysis of variance: One way and two-way classifications (one and multiple but equal observations per cell).

BOOKS RECOMMENDED:

1. Hogg R. V., McKean J. W. and Craig A. T., *Introduction to Mathematical Statistics*, Pearson, 2005, Sixth Edition.
2. Gupta S. C. and Kapoor V. K., *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, 2014, Eleventh Edition.
3. Fisz M., *Probability Theory and Mathematical Statistics*, John Wiley & Sons, 1967, Third Edition.
4. Gun A. M., Gupta M. K. and Dasgupta B., *Fundamentals of Statistics (Vol-I)*, World Press, 2013.
5. Feller W., *An Introduction to Probability Theory and Its Applications (Vol-I)*, John Wiley & Sons, 2003, Third Edition.

Course Outcomes After completion of this course, the students will

- Learn the different distributions, estimation theory and testing of hypothesis.
- Be able to use efficiently statistical tools in solving real life problems.
- Be able to analyze the hypothesis/hypotheses using different tests of significance.

Course Title: Differential Geometry
Course Code: MSM-403

L	T	P
4	1	0

Unit I

Theory of Space Curves: Tangent, principal normal, bi-normal, curvature and torsion. Serretfrenet formulae.Contact between curves and surfaces. Locus of centre of curvature, spherical curvature, Helices.

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Unit II

Spherical indicatrix, Bertrand curves, surfaces, envelopes, edge of regression, developable surfaces, two fundamental forms.

Unit III

Curves on a surface, Conjugate Direction, Principle Directions, Lines of Curvature, Principal Curvatures, Asymptotic Lines. Theorem of Beltrami and Enneper, Mainardi- Codazzi equations.

Unit IV

Geodesics, Differential Equation of Geodesic, torsion of Geodesic, Geodesic Curvature, Clairaut's theorem, Gauss- Bonnet theorem, Joachimsthal's theorem, Geodesic Mapping, Tissot's theorem.

BOOKS RECOMMENDED:

1. Weatherburn, C.E., *Differential Geometry of Three Dimensions*, Cambridge University Press, 2016.
2. Willmore, T.J., *Introduction to Differential Geometry*, Dover Publications Inc., United States, 2012.
3. Bansi Lal, *Differential Geometry, 4th Edition.* Atma Ram & Sons, India, 1976.

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Elective Subjects

Course Title: Coding Theory
Course Code: MSM-501

L	T	P
4	1	0

Unit-I

Introduction to Coding Theory: Code words, distance and weight function, Nearest-neighbour decoding principle, Error detection and correction, Matrix encoding techniques, Matrix codes, Group codes, decoding by coset leaders, Generator and parity check matrices, Syndrome decoding procedure, Dual codes.

Unit-II

Linear Codes: Linear codes, Matrix description of linear codes, Equivalence of linear codes, Minimum distance of linear codes, Dual code of a linear code, Weight distribution of the dual code of a binary linear code, Hamming codes.

Unit-III

BCH Codes: Polynomial codes, Finite fields, Minimal and primitive polynomials, Bose-Chaudhuri-Hocquenghem codes.

Unit-IV

Cyclic Codes: Cyclic codes, Algebraic description of cyclic codes, Check polynomial, BCH and Hamming codes as cyclic codes. Maximum distance separable codes, Necessary and sufficient conditions for MDS codes, Weight distribution of MDS codes, An existence problem, Reed-Solomon codes.

BOOKS RECOMMENDED

1. Vermani L R, *Elements of Algebraic Coding Theory*, Chapman and Hall, 1996.
2. Vera P., *Introduction to the Theory of Error Correcting Codes*, John Wiley and Sons, 1998.
3. Roman Steven, *Coding and Information Theory*, Springer Verlag, 1992.
4. Garrett Paul, *The Mathematics of Coding Theory*, Pearson Education, 2004.

Course Title: Operations Research
Course Code: MSM-502

L	T	P
4	1	0

UNIT-I

Formulation of linear programming problem (LPP) -graphical method, Basic Feasible Solution, Extreme Points, Convex set, Convex linear combination, optimal solution of LPP using Simplex, Big-M and two-phase methods, Exceptional cases in LPP i.e., Infeasible, unbounded, alternate and degenerate solutions.

UNIT-II

General Primal-Dual pair, Formulating a dual problem, Weak and strong duality theorems, Complementary slackness theorem, Dual simplex method, Economic interpretation of primal-Dual problems. Sensitivity analysis: change in right hand side of constraints, change in the objective function and coefficient matrix addition and deletion of constraint and variables.

UNIT-III

Initial basic Feasible solution of transportation problem, Balanced and unbalanced transportation problems, Optimal solutions of transportation problem using U-V /MODI methods, Assignment problems; Mathematical formulation of assignment problem, typical assignment problem, the traveling salesman problem, Test for optimality, degeneracy, Project management with critical path method.

UNIT-IV

Concept of convexity and concavity, Maxima and minima of convex functions, Single and multivariate unconstrained problems, constrained programming problems, Kuhn-Tucker conditions for constrained programming problems, Quadratic programming, Wolfe's method.

BOOKS RECOMMENDED

1. Taha, H.A., *Operations Research-An Introduction,* PHI, 2007.
2. Kanti Swarup, Gupta, P.K. and Man Mohan, *Operations Research*, Sultan Chand & Sons, Ninth Edition, 2002.
3. Hillier, F.S. and Lieberman, G.J., *Operations Research, Second Edition,* Holden-Day Inc, USA, 1974.
4. Bazaraa, M.S., Sherali, H.D., Shetty, C.M., *Nonlinear Programming: Theory and Algorithms,* John Wiley and Sons, 1993.
5. Chandra, S., Jayadeva, and Mehra, A., *Numerical Optimization and Applications,* Narosa Publishing House, 2013.

Course Title: Advanced Complex Analysis
Course Code: MSM-503

L	T	P
4	1	0

Unit-I

Analytic continuation, Analytic continuation by power series method, Natural boundary, Schwarz reflection principle, Analytic continuation along a path, Monodromy theorem, Runge's theorem, simple connectedness, Mittag-Leffler's theorem.

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Unit-II

Maximum principle, Schwarz's Lemma, Hadamard's three circle theorem, Phragmen-Lindelof theorem, Weierstrass factorization theorem, Factorization of sine function, Gamma function. Entire functions, Jensen's formula, the genus and order of an entire function, Hadamard factorization theorem.

Unit-III

Harmonic functions, Basic properties, Harmonic functions on a disc, Subharmonic and Superharmonic functions, The Dirichlet problem, Green's function.

Unit-IV

Normal families of analytic functions, Montel's theorem, Hurwitz's theorem, Riemann mapping theorem, Univalent function, Distortion and Growth theorem for the class of normalized univalent functions, Covering theorem, starlike functions, convex functions, Subordination principle.

BOOKS RECOMMENDED

1. Nihari, Z., Conformal Mapping, Conformal Mapping, McGraw-Hill,1952.
2. Conway, J.B., Functions of One Complex Variable, Springer-Verlag,1973
3. Gamelin, T.W., Complex Analysis, Springer, 2004.
4. Tutschke, W. and Vasudeva, H.L., An Introduction to Complex Analysis- Classical and Modern Approaches, Chapman & Hall/CRC, 2005
5. Copson, E.T., An Introduction to Theory of Functions of a Complex Variable.

Course Title: Advanced Operations Research
Course Code: MSM-504

L	T	P
4	1	0

Unit I

Advanced Linear Programming: Revised simplex method, Sensitivity analysis, Parametric programming, Integer programming branch and bond algorithm, Goal programming, Standard form of LGPP, Partitioning algorithm.

Unit II

Game Theory: Two person zero sum games pure strategies (minmax and maximum principles), Game with saddle point, Mixed strategies: Game without saddle point, Rule of Dominance, Solution methods for games without saddle point: Graphical method, Linear programming method.

Unit III

Dynamic Programming: Characteristics of dynamic programming, Recursive relations, continuous and discrete cases, forward recursion, linear programming versus dynamic programming, Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.

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Unit IV

Inventory Models: Deterministic models: Classic EOQ (Economic order quantity) models, EOQ with price brakes, Multi item EOQ with storage limitation, Dynamic EOQ models(b) Probabilistic models: Probabilistic EOQ models, Single period models and multiperiod models.

Books Recommended

1. Taha, H.A., *Operations Research- An introduction*, 8th Edition, PHI, 2007.
2. Sharma, J.K, *Operation research: Theory & Applications*, 3rd Edition, Macmillan India, 2007.
3. Kasana, H.S and Kumar K.D, *Introductory Operations Research: Theory & Applications*, Springer, 2005.
4. Pant, J.C, Introduction to Optimization and Operations Research, Jain Brothers, 2004.

Course Title: Advanced Fluid Mechanics
Course Code: MSM-505

L	T	P
4	1	0

UNIT-I

Basic Concepts: Continuum Hypothesis, Viscosity, Most general motion of a fluid element, Rate of strain quadric, stress at a point, Tensor character of stress matrix, Symmetry of stress matrix, stress quadric, Stress in a fluid at rest, stress in a fluid in motion, Relation between stress and rate of strain components (Stoke's law of friction), Thermal conductivity, Generalized law of heat conduction, Fundamental equations of the flow of viscous fluids: Equation of state, equation of continuity - Conservation of mass, Equation of motion- Navier-Stoke's equations, Equation of energy- Conservation of energy, Symmetry of fundamental equations, Vorticity and circulation in a viscous incompressible fluid motion, (a) velocity transport equation, (b) Circulation

UNIT-II

Dynamical similarity and Dynamical Analysis: Dynamical similarity, Reynold's law, Inspection analysis, Dimensional analysis, Buckingham π-theorem. Method of finding out the pi-products, Application of pi- theorem to viscous and compressible fluid. Physical importance of non-dimensional parameters. Reynolds number, Eckert Number, Froude Number, Mach Number, Pecklet Number, Grashoff Number, Prandtl Number, Brinkman Number, Nussel Number. Exact Solution of Navier-Stoke's equations of motion- Flow between parallel plates (Velocity and temperature distributions), (i) Plane Couette flows (ii) Plane Poiseulle Flow and (iii) Generalized Couette flow.

UNIT-III

Flow in a circular pipe (Hagen Poiseuille flow) -Velocity and temperature distribution, Flow through tubes of uniform cross section in the form of circle, annulus, ellipse and equilateral triangle under constant pressure gradient. Flow between two concentric rotating cylinders (Couette flow) , Flow in convergent and divergent channels,

UNIT-IV

Steady incompressible flow with variable viscosity: Variable viscosity plane Couette flow and plane poiseulle flow. Unsteady incompressible flow with constant fluid properties: Flow due to a plane wall suddenly set in motion, flow due to an oscillating plane wall, starting flow in plane Couette motion, Starting flow in pipes, Plane coquette flow with transpiration cooling.

Books Recommended

1. Bansal, J L, *Viscous Fluid Dynamics*, OXFORD & IBH Publishing Company Pvt. Ltd., New Delhi, 1992.

2. Chorlton, F., *Textbook of Fluid Dynamics*, C.B.S. Publishers, Delhi, 1985.

3. Schlichting, H., *Boundary Layer Theory*, McGraw Hill Book Company, New York, 1979.

4. Young, A. D., *Boundary Layers*, AIAA Education Series, Washington DC, 1989.

5. Yuan, S.W., *Foundations of Fluid Mechanics*, Prentice Hall of India Private Limited, New Delhi, 1976

Course Title: Advanced Solid Mechanics
Course Code: MSM-506

L	T	P
4	1	0

Unit-I

Basics and Extension of Beams: Hooke's law, generalized Hooke's law, Elastic moduli and their relationship, strain-energy density function and its connection with Hooke's law, Saint-Venant's principle. Extension of beams: extension of beams by longitudinal forces, beam stretched by its own weight and bending of beams by terminal couples.

Unit-II

Torsion and flexure of beams: Torsion of a circular shaft, cylindrical bars, and elliptic cylinder. Stress function, conformal mapping, solution of torsion problem by conformal mapping. Flexure of beams by terminal loads, bending of rectangular beams.

Unit-III

Two-and Three-dimensional Problems: Plane deformation, plane stress, plane elastostatic problems, Airy's stress function, solution of the bi-harmonic equation, stress and displacement formulae basic problems of circular region: uniform pressure, uniform radial displacement and concentrated loads. Spherical shell under external and internal pressures.

Unit-IV

Thermoelastic problems and Variational Methods: Thermal stresses in spherical bodies, two-dimensional thermoelastic problems. Variational methods: Theorems of potential energy, minimum

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complementary energy, work and reciprocity, Ritz method for one- and two-dimensional problems and Galerkin's method. Kantorovich and Trefftz methods. Application of Treffz method.

Books Recommended

1. Sokolnikoff, I.S., *Mathematical Theory of Elasticity*, TMH, New Delhi 1978.

2. Timoshenko.S. and Young D.H., *Elements of strength of materials Vol. I & Vol. II*, T. Van Nostrand Co-Inc Princeton, N.J., 1990.

3. Love, A.E.H, *A Treatise on the Mathematical theory of Elasticity,* Cambridge University Press, 1963.

Course Title: Theory of Linear Operators
Course Code: MSM-507

L	T	P
4	1	0

Unit I

Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators. Properties of resolvent and spectrum. Spectral mapping theorem for polynomials.

Unit II

Elementary theory banach algebra, Spectral radius of a bounded linear operator on a complex banach space.

Unit III

General properties of compact linear operators. Spectral properties of compact linear operators on normed spaces. Behaviors of compact linear operators with respect to solvability of operator equations. Fredholm type theorems. Fredholm alternative theorem. Fredholm alternative for integral equations.

Unit IV

Spectral properties of bounded self-adjoint linear operators on a complex Hilbert space. Positive operators. Monotone Sequences theorem for bounded self-adjoint operators on a complex Hilbert space, Square roots of a positive operator.

Books Recommended

1. Kreyszig E., *Introductory functional analysis with applications,* Johan-Wiley & Sons, New York, 1978.

2. Halmos P.R., *Introduction to Hilbert space and the theory of spectral multiplicity*, 2nd Edition. Chelsea Pub., Co., N.Y. 1957.

3. Dunford N. and Schwartz, J.T., *Linear operators-3 parts*, Inter-science Wiley, New York, 1958-71.

4. Bachman G. and Narici, L., *Functional analysis*, Academic Press, New York, 1998.

Course Title: Advanced Numerical Methods
Course Code: MSM-508

L	T	P
4	1	0

Unit-I

Iterative Methods for Linear Systems: The classical iterative methods (Jacobi, Gauss-Seidel and Successive Over Relaxation (SOR) methods), Krylov subspace methods; Conjugate gradient, Bi-conjugate-gradient (BiCG), BiCG stability methods, Preconditioning techniques, parallel implementations.

Unit-II

Finite Difference Methods: Explicit and implicit schemes, consistency, stability and convergence, Lax equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

Unit-III

Approximate methods of solution: Rayleigh-Ritz, collocation and Galerkin methods, properties of Galerkin approximations, Petrov-Galerkin method, Generalized Galerkin method.

Unit-IV

Finite Element Method (FEM): FEM for second order problems, One- and two-dimensional problems, The finite elements (elements with a triangular mesh and a rectangular mesh and three-dimensional finite elements), Fourth-order problems, Hermite families of elements, iso-parametric elements, numerical integration.

BOOKS RECOMMENDED:

1. Jain, M.K, Iyengar, S.R.K. and Jain, R.K., *Numerical Methods for Scientific and Engineering Computation*, 5th Edition, New Age international, 2008.

2. Hoffman Joe D., *Numerical methods for Engineers and Scientists*, McGrow-Hill, 1993.

3. Atkinson, K.E, *An Introduction to Numerical Analysis*, 2nd Edition, *John Wiley*, 2004.

4. Gupta R.S., *Elements of Numerical Analysis*, McMillan India, 2009

5. Seshu P., *Textbook of Finite Element Analysis*, Prentice Hall India, 2003.

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Course Title: Topological Vector Spaces
Course Code: MSM-509

L	T	P
4	1	0

Unit-I

Review of basic concepts of topological spaces and vector spaces. Prodect topological spaces, projection maps, compactness of prodect topological spaces-Tichonov's theorem.

Topological vector spaces (TVSs), examples of TVSs, Normed vector spaces as TVSs, Translation and multiplication maps, Neighborhood of 0, separated TVS, linear maps between TVSs, Bounded subsets of a topological vector space.

Unit-II

Locally convex topological spaces, normable and metrizable topological vector spaces, complete topological vector spaces

Unit-III

Frechet spaces, Uniform boundedness principle, open mapping and closed graph theorems for Frechet spaces.

Unit-IV

Banach-Alaoglu theorem, Variational inequalities, Lion-Stampacchia theory, Physical phenomenon represented by variational inequalities, points and external sets-Krein Miliman theorem.

BOOKS RECOMMENDED:

1. Munkres J. R., *Topology – A First Course*, Prentice-Hall of India, 1978.
2. Kelley, J.L., *Linear topological spaces*, Van Nostrand East West Press, New Delhi.
3. Wilansky A., *Modern Methods in Topological Vector Spaces,* McGraw Hill, 1978.
4. Simmons G. F., *Introduction to Topology and Modern Analysis*, McGraw-Hill, 1963.
5. Rudin W., *Functional Analysis*, 2nd Edition, McGraw Hill, 1973.

Course Title: Fractional Calculus
Course Code: MSM-510

L	T	P
4	1	0

Unit-I

Special Functions of the Fractional Calculus. Gamma Function. Mittag-Leffler function, Fractional Derivatives and Integrals. Grunwald-Letnikov Fractional Derivatives. Riemann Liouville Fractional Derivatives. Some Other Approaches.

Unit-II

Geometric and Physical Interpretation of Fractional Integration and Fractional Differentiation. Sequential Fractional Derivatives. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives. Fourier Transforms of Fractional Derivatives. Mellin Transforms of Fractional Derivatives.

Unit-III

Linear Fractional Differential Equations. Fractional Differential Equation of a General Form. Existence and Uniqueness Theorem as a Method of Solution. Dependence of a Solution on Initial Conditions. The Laplace Transform Method. Standard Fractional Differential Equations. Sequential Fractional Differential Equations. Fractional Green's Function. Definition and Some Properties. One-Term Equation. Two Term Equation. Three-Term Equation. Four-Term Equation. General Case: n-term Equation.

Unit-IV

Other Methods for the Solution of Fractional-order Equations. The Mellin Transform Method. Power Series Method. Babenko's Symbolic Calculus Method. Method of Orthogonal Polynomials. Numerical Evaluation of Fractional Derivatives. Approximation of Fractional Derivatives. Order of Approximation. Computation of Coefficients. Higher-order Approximations.

Books Recommended

1. Podlubny, I., *Matrix approach to discrete fractional calculus vol. 3*, Fractional Calculus and Applied Analysis, 2000.

2. Carpinteri A, Mainardi F, editors. *Fractals and fractional calculus in continuum mechanics,* New York, Springer-Verlag Wien, 1997.

3. Mandelbrot B.B., *The fractal geometry of nature,* New York, W. H. Freeman, 2000.

4. Miller K.S., Ross B., *An introduction to the fractional calculus*. New York, John Wiley, 1993.

5. Oldham KB, Spanier J., *The fractional calculus,* New York, Academic Press; 1974.

Course Title: Discrete Mathematics
Course Code: MSM-511

L	T	P
4	1	0

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Unit-I

Mathematical Logic: Basic logical operations, conditional and bi-conditional statements, tautologies, contradiction, predicate calculus and its inference theory.

Recursion and Recurrence Relations: Polynomial expressions, telescopic form, recursion theorem, closed form expression, generating function, solution of recurrence relation using generating function, recursion.

Unit-II

Lattices and Boolean Algebra: Introduction to Binary relations, equivalence relations and partitions, Partial order relations, Hasse diagram. Lattices as partially ordered sets, properties, lattices as algebraic systems, sub lattices, direct products, Homomorphism, some special lattices. Boolean algebra as lattices, Boolean identities, sub-algebra, Boolean forms and their equivalence, sum of product, product of some canonical forms. Applications of Boolean algebra to circuit theory.

Unit-III

Graph Theory: Directed graphs, undirected graphs, paths, circuits, cycles, sub-graphs, induced Sub graphs, degree of vertex, connectivity, planner graph, complete, bi-partite complete graph, matrix representation of graph, adjacency and incidence matrix for graph, Eulerian paths and circuits, Trees and Coloring of the graph, Rooted tree, search tree, tree traversals, spanning trees, minimal spanning trees, Kruskal's algorithm. Chromatic number and polynomial, four-color problem (statement only).

Unit-IV

Algebraic Structures: Review of groups, codes and group codes, cyclic codes and coding methods based on entropy, Application of algebraic structure to error corrections and detection codes, discrete codes and first coding theorem.

BOOKS RECOMMENDED:

1. Tremblay, J.P. and Manohar, R.P., *Discrete Mathematics with Applications to Computer Science*, Tata McGraw Hill, 2008.
2. Ram, Babu, *Discrete Mathematics*, Pearson Education, 2007.
3. Harary, F., *Graph Theory*, Narosa, 1995
4. Doerr, Alan and Levsseur, K., *Applied Discrete Structures for Computer Science,* Galgotia Publication, 2005.
5. Liu, C.L, *Elements of Discrete Mathematics*, 3rd Edition, Tata McGraw Hill, 2008.
6. Grimaldi, R.P and Ramana, B.V., *Discrete and Combinatorial Mathematics-An Applied Introduction*, Pearson education, 5th Edition, 2004.
7. Lipschultz, S., *Theory and Practice of Data Structures*, McGraw-Hill, 1988.

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M.Sc. Mathematics

Course Structure and Syllabus
University Campus
(Based on Choice Based Credit System)
2018 onwards

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DEPARTMENT OF MATHEMATICAL SCIENCES

VISION

To be a knowledge nerve center in Mathematics, Pure and Applied Research and industry requirements for creating sustainable infrastructure and enhancing quality of life.

MISSION

1. To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Mathematical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation;
2. To develop and conduct continuing education programs for Science graduates with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University;
3. To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit.

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M.Sc. (Mathematics) Program

The main objective of this program is to cultivate a mathematical aptitude and nurture the interests of the students towards problem solving aptitude. Further, it aims at motivating the young minds for research in mathematical sciences and to train computational scientists who can work on real life challenging problems.

Duration: M.Sc. Mathematics is a postgraduate level program offered by the Department of Mathematical Sciences. This is a 2-years program, consisting of four semesters with two semesters per year.

Program Code: MSM (Masters of Science in Mathematics)

Eligibility: B.A./B.Sc. or equivalent from a recognized university with Mathematics as one of the major subjects with at least 50% marks in aggregate.

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PROGRAM OBJECTIVES: The Program Objectives are the knowledge skills and attributes which the students have at the time of post-graduation. At the end of the program, the student will be able to:

1	To provide comprehensive curriculum to groom the students into qualitative scientific manpower
2	Enable students to enhance mathematical skills and understand the fundamental concepts of pure and applied mathematics.
3	To provide qualitative education through effective teaching learning processes by introducing projects, participative learning and latest software tools.
4	To inculcate innovative skills, team work, ethical practices among students so as to meet societal expectations.
5	To encourage collaborative learning and application of mathematics to real life situations.
6	To inculcate the curiosity for mathematics in students and to prepare them for future research.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

PSO1	Apply the knowledge of mathematical concepts in interdisciplinary fields.
PSO2	Understand the nature of abstract mathematics and explore the concepts in further details.
PSO3	Model the real-world problems in to mathematical equations and draw the inferences by finding appropriate solutions.
PSO4	Identify challenging problems in mathematics and find appropriate solutions.
PSO5	Pursue research in challenging areas of pure/applied mathematics.
PSO6	Employ confidently the knowledge of mathematical software and tools for treating the complex mathematical problems and scientific investigations.
PSO7	Continue to acquire mathematical knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematics.
PSO8	Comprehend and write effective reports and design documentation related to mathematical research and literature, make effective presentations.
PSO9	Qualify national level tests like NET/GATE etc.
PSO10	Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in society.

Scheme of the Program:

First Semester **Contact Hours: 28 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
UC-MSM-101-18	Algebra-I	4	1	0	40	60	100	4
UC-MSM-102-18	Real Analysis-I	4	1	0	40	60	100	4
UC-MSM-103-18	Complex Analysis	4	1	0	40	60	100	4
UC-MSM-104-18	Ordinary Differential Equations and Special Functions	4	1	0	40	60	100	4
UC-MSM-105-18	Mathematical Methods	4	1	0	40	60	100	4
UC-MSM-106-18	Introduction to Computer Algebra System (Lab)	0	0	3	50	25	75	3
Total		20	05	03	250	325	575	23

Second Semester **Contact Hours: 28 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
UC-MSM-201-18	Algebra-II	4	1	0	40	60	100	4
UC-MSM-202-18	Real Analysis-II	4	1	0	40	60	100	4
UC-MSM-203-18	Mechanics-I	4	1	0	40	60	100	4

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UC-MSM-204-18	Partial Differential Equations	4	1	0	40	60	100	4
UC-MSM-205-18	Numerical Analysis	4	1	0	40	60	100	4
UC-MSM-206-18	Numerical Analysis (Lab)	0	0	3	50	25	75	3
Total		20	05	03	250	325	575	23

Third Semester **Contact Hours: 25 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
UC-MSM-301-18	Topology	4	1	0	40	60	100	4
UC-MSM-302-18	Number Theory and Cryptography	4	1	0	40	60	100	4
UC-MSM-303-18	Mathematical Statistics	4	1	0	40	60	100	4
UC-MSM-304-18	Functional Analysis	4	1	0	40	60	100	4
UC-MSM-305-18	Mechanics-II	4	1	0	40	60	100	4
UC-MSM-311-18	Seminar	0	0	2	50	0	50	2
Total		20	05	00	200	300	500	22

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Fourth Semester **Contact Hours: 27 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution			Credits
			L	T	P	Internal	External	Total	
1.	UC-MSM-401-18	Differential Geometry	4	1	0	40	60	100	4
2.	UC-MSM-WWW-18	Elective	4	1	0	40	60	100	4
3.*	UC-MSM-XXX-18 UC-MSM-YYY-18 UC-MSM-ZZZ-18	Elective	4	1	0	40	60	100	12
	UC-MSM-411-18	Dissertation	-	-	12	200	100	300	
4.	UC-MSM-412-18	Seminar	0	0	2	50	0	50	2
	Total							550	22

TOTAL NUMBER OF CREDITS = 90

Note*: Students may opt either three Elective Theories or Dissertation.

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LIST OF DEPARTMENTAL/INTERDISCIPLINARY ELECTIVES

Elective- UC-MSM-WWW-18, UC-MSM-XXX-18, UC-MSM-YYY-18, UC-MSM-ZZZ-18 (Any one subject to be opted)

MSM-501-18 Discrete Mathematics

MSM-502-18 Coding Theory

MSM-503-18 Operations Research

MSM-504-18 Advanced Number Theory

MSM-505-18 Advanced Complex Analysis

MSM-506-18 Advanced Operations Research

MSM-507-18 Advanced Fluid Mechanics

MSM-508-18 Advanced Solid Mechanics

MSM-509-18 Theory of Linear Operators

MSM-510-18 Advanced Numerical Methods

MSM-511-18 Topological Vector Spaces

MSM-512-18 Fractional Calculus

Examination and Evaluation

Theory			
S. No.	**Evaluation criteria**	**Weightage in Marks**	**Remarks**
1	Mid term/sessional Tests	24	Internal evaluation (40 Marks) MSTs, Quizzes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
2	Attendance	6	
3	Assignments	10	
4	End semester examination	60	External evaluation

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5	Total	100	Marks may be rounded off to nearest integer.
Practical			
1	Evaluation of practical record/ Viva Voice/Attendance/Seminar/ Presentation	30	Internal evaluation
2	Final Practical Performance + Viva-Voce	20	External evaluation
3	Total	50	Marks may be rounded off to nearest integer.
Seminar			
1	Content	15	Internal evaluation
2	Queries	15	
3	Communication skills	10	
4	Visual effects	10	
5	Total	50	Marks may be rounded off to nearest integer.

<table>
<tr><td colspan="7">Dissertation</td></tr>
<tr><td></td><td colspan="4">Internal Assessment</td><td></td><td></td></tr>
<tr><td rowspan="2">Departmental Presentation</td><td colspan="2">Communication and presentation</td><td colspan="2">Response to queries</td><td>Maximum Marks</td><td>Evaluated by</td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td><td>50</td><td>Committee Member:
1.Head
2.Supervisor
3.One of Faculty Member</td></tr>
<tr><td rowspan="2">Dissertation</td><td>Plagiarism</td><td>Subject Matter</td><td>Usage of Language</td><td>Publication/Presentation in Conference</td><td rowspan="2">150</td><td rowspan="2"></td></tr>
<tr><td>25</td><td>70</td><td>25</td><td>30</td></tr>
<tr><td></td><td colspan="4">External Assessment</td><td></td><td></td></tr>
<tr><td rowspan="2">External Examiner</td><td colspan="4">Subject Matter</td><td rowspan="2">50</td><td rowspan="2">Committee Member:
1.Head
2.External Expert
3.Supervisor
4. Director (MC) nominee</td></tr>
<tr><td colspan="4">50</td></tr>
<tr><td rowspan="2">Viva Voce</td><td colspan="2">Communication and Presentation</td><td colspan="2">Response to queries</td><td rowspan="2">50</td><td rowspan="2"></td></tr>
<tr><td colspan="2">20</td><td colspan="2">30</td></tr>
<tr><td colspan="5">Total</td><td>300</td><td></td></tr>
</table>

Evaluation Process:

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1. The subject matter evaluation can further be defined on the basis of Title, Review of literature/Motivation, Objectives, Methodology, Results and discussions, and Conclusion.
2. The usage of language and the subject matter shall be evaluated by the supervisor. Out of 300 marks, 95 marks are to be evaluated by the concerned supervisor.
3. Total 15% Plagiarism is admissible for submission of the dissertation. For (0-5)%of plagiarism, candidate should be awarded 25 marks. For >5%-10% candidate should be awarded 15 marks and for the range of > 10% to < 15%, candidate should be awarded 5 marks.
4. For publication candidate should be awarded full 30 marks and for presenting the work related to dissertation, candidate should be awarded 25 marks.

Instructions for Paper-Setter in M. Sc (Hons.) Mathematics

A. Scope

1. The question papers should be prepared strictly in accordance with the prescribed syllabus and pattern of question paper of the University.
2. The question paper should cover the entire syllabus with uniform distribution among each units and Weightage of marks for each question.
3. The language of questions should be simple, direct, and documented clearly and unequivocally so that the candidates may have no difficulty in appreciating the scope and purpose of the questions. The length of the expected answer should be specified as far as possible in the question itself.
4. The distribution of marks to each question/answer should be indicated in the question paper properly.

B. Type and difficulty level of question papers

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1. Questions should be framed in such a way as to test the students intelligent.grasp of broad principles and understanding of the applied aspects of the subject. The Weightage of the marks as per the difficulty level of the question paper shall be as follows:

   i) Easy question 30%

   ii) Average questions 50%

   iii) Difficult questions 20%

2. The numerical content of the question paper should be up to 40%.

C. Format of question paper

1. Paper code and Paper-ID should be mentioned properly.
2. The question paper will consist of three sections: Sections-A, B and C.
3. Section-A is COMPULSORY consisting of TEN SHORT questions carrying two marks each (total 20 marks) covering the entire syllabus.
4. The Section-B consists of FOUR questions of eight marks each covering Unit I & II of syllabus (Taking two questions from each unit I & II).
5. The Section-C consists of FOUR questions of eight marks each covering Unit III & IV of syllabus (Taking two questions from each unit III & IV).
6. Sub-parts of the questions in Section B and C should be preferred for numerical/conceptual questions.
7. Attempt any five questions from Section-B and Section-C, selecting at least two questions from each of the two sections.

Question paper pattern for MST:

Roll No:	**No of pages:**
IK Gujral Punjab Technical University- Jalandhar	
Department of Mathematical Sciences	
Academic Session:	
Mid-Semester Test: I/II/III (Regular/reappear)	**Date:**
Programme: B.Sc. (Hons.) Mathematics	**Semester:**
Course Code:	**Course:**
Maximum Marks: 24	**Time: 1 hour 30 minutes**

❖ Note: Section A is compulsory; Attempt any two questions from Section B and one question from Section C.

		Marks	Cos
Section: A			
1		2	
2		2	
3		2	
4		2	
Section: B			
5		4	
6		4	
7		4	
Section: C			
8		8	
9		8	

Details of Course Objectives

CO1	
CO2	
CO3	
CO4	
CO5	

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SEMESTER-I

UC-MSM-101-18	Algebra-I	L-4, T-1, P-0	4 Credits
Pre-requisite: Discrete Structures			
Course Objectives: This course is designed to give students a foundation for all future mathematics courses. The fundamentals of algebraic problem-solving are explained. Students will explore: foundations of Algebraic structures, Groups, Rings, Ideals, Fields, Homomorphisms etc. The course also fulfills the objective to make students aware of the applicability of abstract mathematics in real world problems.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Apply the knowledge of Algebra to attain a good mathematical maturity and enables to build mathematical thinking and skill.
CO2	Utilize the class equation and Sylow theorems to solve different related problems.
CO3	Identify and analyze different types of algebraic structures such as Solvable groups, Simple groups, Alternate groups to understand and use the fundamental results in Algebra.
CO4	Design, analyze and implement the concepts of homomorphism and isomorphism between groups and rings for solving different types of problems, for example, Isomorphism theorems, quotient groups, conjugacy etc.
CO5	Create, select and apply appropriate algebraic structures such as finitely generated abelian groups, Ideals, Fields to explore the existing results.
CO6	Identify the challenging problems in modern mathematics and find their appropriate solutions.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	√	√	-	√	-	√	√
CO2	√	√	-	√	-	-	√	-	√	√
CO3	√	√	-	√	√	-	√	-	√	√
CO4	√	√	-	√	√	-	√	-	√	√
CO5	√	√	-	√	-	-	√	-	√	√
CO6	√	√	-	√	-	-	√	-	√	√

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Course Title: Algebra-I
Course Code: UC-MSM-101-18

UNIT-I

Groups: Groups, homomorphisms, Subgroups and Cosets, Cyclic groups, Permutation groups, Normal subgroups and quotient groups, Isomorphism theorems, Automorphisms, Symmetric groups, Conjugacy. [Ref 2: Unit 1]

UNIT-II

Normal series, Derived Series, Composition Series, Solvable Groups, Simple groups and their examples, Alternating group A_n, Simplicity of A_n. [Ref 2: Unit 1]

UNIT-III

Direct Products, Finite Abelian Groups, Fundamental Theorem on Finitely generated Abelian Groups, Invariants of a finite abelian groups, Sylow's Theorems and their applications, Groups of order p^2, pq. [Ref 2: Unit 1]

UNIT-IV

Rings: Ring, Subring, Ideals, Homomorphism and Algebra of Ideals, Maximal and prime ideals, Ideals in quotient rings, Nilpotent and nil ideals. [Ref 2: Unit 2]

RECOMMENDED BOOKS:

1. Bhattacharya, P. B., Jain, S.K. and Nagpaul, S.R., *Basic Abstract Algebra, 2nd Edition*. U.K.: Cambridge University Press, 2004.
2. Dummit, David. S., and Foote, Richard M., *Abstract Algebra, 3rd Edition*. New Delhi: Wiley, 2011.
3. Herstein, I.N., *Topics in Algebra, 2nd Edition*. New Delhi: Wiley, 2006.
4. Singh, Surjeet, and Zameeruddin, Q., *Modern Algebra, 7th Edition*. New Delhi: Vikas Publishing House, 1993.
5. Artin, M., *Algebra, 2nd Edition*. Pearson Publications, 2010.

UC-MSM-102-18	Real Analysis-I	L-4, T-1, P-0	4 Credits

Pre-requisite: Basic Calculus

Course Objectives: This course is designed to provide a deeper and rigorous understanding of fundamental concepts viz. metric spaces, continuous functions, sequences and series of numbers as well as functions, and the Riemann-Stieltjes integral etc. The main focus of this course will be on theoretical foundation of the above said concepts and it will cultivate the rigorous mathematical logics and skills in the students.

Course Outcomes: At the end of the course, the students will be able to

CO1	Apply the knowledge of concepts of real analysis in order to study theoretical development of different mathematical techniques and their applications.
CO2	Understand the nature of abstract mathematics and explore the concepts in further details.
CO3	Identify challenging problems in real variable theory and find their appropriate solutions.
CO4	Deal with axiomatic structure of metric spaces and generalize the concepts of sequences and series, and continuous functions in metric spaces.
CO5	Use theory of Riemann-Stieltjes integral in solving definite integrals arising in different fields of science and engineering.
CO6	Extend their knowledge of real variable theory for further exploration of the subject for going into research.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	-	-	-	√	-	√	√
CO2	-	√	-	-	-	-	√	-	√	√
CO3	-	-	-	√	-	-	√	-	√	√
CO4	-	√	-	-	-	-	√	-	√	√
CO5	√	-	-	-	-	-	√	-	√	√
CO6	-	-	-	-	√	-	√	-	√	√

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Course Title: Real Analysis-I
Course Code: UC-MSM-102-18

UNIT-I

Finite, Countable and Uncountable sets, Metric spaces, Compact sets, Perfect sets, Connected sets, Convergent sequences, Sub sequences, Cauchy sequences, Power series, Absolute convergence, Algebra of series, Rearrangements of elements in a series.

UNIT-II

Limits of functions, Continuous functions, Compactness, Connectedness, Monotonic functions, Infinite limits and Limits at infinity.

UNIT-III

The Riemann-Stieltjes integral: Definition and existence of the Riemann-Stieltjes integral, Properties of the integral, Integration and differentiation, Integration of vector-valued functions, Rectifiable curves.

UNIT-IV

Sequences and series of functions: Interchanging order of limits for sequences of functions, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, Stone Weierstrass Theorem.

RECOMMENDED BOOKS:

1. Rudin, W., *Principles of Mathematical Analysis, 3rd Edition*. New Delhi: McGraw-Hill Inc., 2013.
2. Royden, H.L. and Fitzpatrick, P.M., *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.
3. Carothers, N. L., *Real Analysis*, Cambridge University Press, 2000.
4. Apostol, T.M., *Mathematical Analysis –A modern approach to Advanced Calculus*. New Delhi: Narosa Publishing House, 1957.
5. Abbott, S., *Understanding Analysis, 2nd Edition.* Springer, 2016.

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UC-MSM-103-18	Complex Analysis	L-4, T-1, P-0	4 Credits

Pre-requisite: Calculus of several variables and complex number system.

Course Objectives: The objective of this course is to introduce and develop a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions and to make students equipped with the understanding of the fundamental concepts of complex variable theory. In particular, to enable students to acquire skill of contour integration to evaluate complicated real integrals via residue calculus.

Course Outcomes: At the end of the course, the students will be able to

CO1	Know the fundamental concepts of complex analysis.
CO2	Evaluate complex integrals and apply Cauchy integral theorem and formula.
CO3	Evaluate limits and checking the continuity of complex function & apply the concept of analyticity and the Cauchy-Riemann equations.
CO4	Solve the problems using complex analysis techniques applied to different situations in engineering and other mathematical contexts.
CO5	Establish the capacity for mathematical reasoning through analysing, proving and explaining concepts from complex analysis
CO6	Extend their knowledge to pursue research in this field.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	-	√	-	√	-	√	√
CO2	√	√	-	√	√	-	√	-	√	√
CO3	√	√	-	√	√	-	√	-	√	√
CO4	√	√	√	√	√	-	√	-	√	√
CO5	√	√	√	√	√	-	√	-	√	√
CO6	√	√	√	√	√	-	√	-	√	√

Course Title: Complex Analysis

Course Code: UC-MSM-103-18

UNIT-I

Function of complex variable, continuity and differentiability, Analytic functions, Cauchy Riemann equation (Cartesian and polar form). Harmonic functions, Harmonic conjugate, Construction of analytic functions. Exponential function, Trigonometric and inverse trigonometric functions, Logarithmic function, Complex powers, Branches of multivalued functions with reference to arg(z), log(z), z^c. Stereographic projection and the spherical representation of the extended complex plane.

Unit-II

Complex line integral, Cauchy-Goursat theorem, independence of path; Cauchy's integral formulas and their consequences, Cauchy inequality, Liouville's theorem, Fundamental theorem of algebra, Morera's theorem, Maximum modulus principle, Schwarz lemma, Poisson's integral formula.

Unit-III

Power series: circle of convergence, radius of convergence. Taylor's series and Taylor's theorem, Laurent'z series and Laurent theorem, Zeros and singularities of complex functions, classification of singularities: removable singularity, poles, essential singularities, Residue at a pole and at infinity, Cauchy's Residue theorem and its applications in evaluation of real integrals: integration around unit circle, integration over semi-circular contours (with and without real poles), integration around rectangular contours, Argument principle, Rouche's theorem

Unit-IV

Conformal transformations, Bilinear transformations, Critical points, Fixed points, Problems on cross-ratio and bilinear transformation.

RECOMMENDED BOOKS:

1. Ahlfors, L.V., *Complex Analysis, 2nd Edition*. McGraw-Hill International Student Edition, 1990.
2. Kumar, R.R., Complex Analysis, Pearson Education, 2015.
3. Churchill, R. and Brown, J.W., *Complex Variables and Applications, 6th Edition*. New- York: McGraw-Hill, 1996.

UC-MSM-104-18	**Ordinary Differential Equations and Special Functions**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Differential Calculus, Integral Calculus and some introduction to linear algebra.	
Course Objectives: The Objective of this course is to introduce ordinary differential equations and fundamental theorems for existence and uniqueness. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations appearing in various fields of science and technology.	
Course Outcomes: At the end of the course, the students will be able to	
CO1	Understand ordinary differential equations of various types, their solutions, and fundamental concepts about their existence.
CO2	Understand the concept and applications of eigen value problems.
CO3	Understand differential equations of Strum Liouville type.
CO4	Apply various power series methods to obtain series solutions of differential equations.
CO5	Discuss various kinds of special functions in detail, their properties and relations.
CO6	Solve problems of ordinary differential equations arising in various fields.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	√	-	√	√
CO2	√	-	√	√	√	-	√	-	√	√
CO3	√	-	√	√	√	-	√	-	√	√
CO4	√	-	√	√	√	-	√	-	√	√
CO5	√	-	√	√	√	-	√	-	√	√
CO6	√	-	√	√	√	-	√	-	√	√

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Course Title: Ordinary Differential Equations and Special Functions

Course Code: UC-MSM-104-18

UNIT-I

Review of linear differential equations with constant & variable coefficients. Fundamental existence and uniqueness theorem for system and higher order equations (Picard's and Piano theorems), System of linear differential equations, an operator method for linear system with constant coefficients, Phase plane method.

UNIT-II

Homogeneous linear system with constant coefficients. Eigenvalues and eigen functions, orthogonality of eigen functions, Complex eigenvalues, repeated eigenvalues, Ordinary differential equations of the Sturm-Liouville problems, Expansion theorem, Extrema properties of the eigen values of linear differential operators, Formulation of the eigen value problem of a differential operator as a problem of integral equation, Linear homogeneous boundary value problems

UNIT-III

Power series solution of differential equations: about an ordinary point, solution about regular singular points, the method of Frobenius, Bessel equation and Bessel functions, Recurrence relations and orthogonal properties., Series expansion of Bessel Coefficients, Integral expression, Integral involving Bessel functions, Modified Bessel function, Ber and Bei functions, Asymptotic expansion of Bessel Functions, Legendre's differential equations, Legendre Polynomials , Rodrigue's formula, Recurrence relations and orthogonal properties.

UNIT-IV

The Hermite polynomials, Chebyshev's polynomial, Laugrre's polynomial: Recurrence relations, generating functions and orthogonal properties.

RECOMMENDED BOOKS:

1. Ross, S.L., *Differential Equations, 3rd Edition*. John Wiley & Sons, 2004.
2. Boyce, W.E. and Diprima, R.C., *Elementary Differential Equations and Boundary Value problems, 4th Edition*. John Wiley and Sons, 1986.
3. Sneddon, I.N., *Special Functions of Mathematical Physics and Chemistry*. Edinburg: Oliver & Boyd, 1956.
4. Bell, W.W., *Special Functions for Scientists and Engineers*. Dover, 1986.

UC-MSM-105-18	**Mathematical Methods**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Basic Calculus and Linear Algebra			
Course Objectives: The objective of the course is to acquaint the students with the knowledge of mathematical techniques frequently applied in various branches of engineering and sciences. Also, one of the objectives of this course is to equip the students with the mathematical background required for the development of such techniques.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Understand the theory and applications of integral transforms.
CO2	Explain how integral transforms can be used to solve a variety of differential equations.
CO3	Solve integro-differential equations of Fredholm and Volterra type.
CO4	Understand the properties of various kinds of integral equations.
CO5	Develop their attitude towards problem solving.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	√	-	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

Course Title: Mathematical Methods
Course Code: UC-MSM-105-18

UNIT I

Laplace Transforms: Laplace Transform, Properties of Laplace Transform, Inverse Laplace Transform, Convolution theorem, Laplace transform of periodic functions, unit step function and impulsive function, Application of Laplace Transform in solving ordinary and partial differential equations and Simultaneous linear equations;

UNIT II

Fourier Transforms: Fourier transform, properties of Fourier transform, inversion formula, convolution, Parseval's equality, Fourier transform of generalized functions, application of Fourier transforms in solving heat, wave and Laplace equation. Fast Fourier transform.

UNIT III

Integral Equations: Relations between differential and integral equations, Green's function, Linear equations in cause and effect, Integral equations of Fredholm and Volterra type, solution by successive substitution and successive approximation, integral equations with degenerate kernels.

UNIT IV

Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems, integral equations with symmetric kernel, Solutions with separable kernels, Characteristic numbers, Resolvent kernel, Eigen values and Eigen functions of integral equations and their simple properties.

Text and Reference Books:

1. Sneddon, I.N., *The Use of Integral Transforms*. McGraw Hill, 1985.
2. Goldberg, R.R., *Fourier Transforms.* Cambridge University Press, 1970.
3. Smith, M.G., *Laplace Transform Theory*. Van Nostrand Inc., 2000.
4. Elsegolc, L., *Calculus of Variation*. Dover Publications, 2010.
5. Kenwal, R.P., *Linear Integral Equation; Theory and Techniques*. Academic Press, 1971.
6. Hildebrand, F.B., *Methods of Applied Mathematics* ***(Latest Reprint)***. Dover Publications.
7. Pal, S. and Bhunia, S.C., *Engineering Mathematics*. Oxford University Press, 2015.

UC-MSM-106-18	Introduction to Computer Algebra System	L-0, T-0, P-3	3 Credits

Pre-requisite: Basic knowledge of computer

Course Objectives: This course provides an introduction to Computer Algebra System (CAS) viz. MATLAB and MATHEMATICA that are widely used in scientific computing. The major objective of this course is to enable students to make use of symbol tools of these CAS and also develop programming skills for solving problems of real world more efficiently and accurately

Course Outcomes: At the end of the course, the students will be able to

CO1	Apply the knowledge of mathematical software viz. MATLAB and MATHEMATICA to solve real world problems efficiently.
CO2	Utilize the symbolic tools of these CAS for handling different mathematical problems for example, solution of equations, differentiation, integration etc.
CO3	Design and analyze their own computer codes of mathematical methods.
CO4	Understand and modify existing codes in scientific computing based on the use of different loops and conditional structures.
CO5	Use these CAS with the understanding of limitations of the systems.
CO6	Identify the challenging problems in mathematics and find their appropriate solutions accurately and efficiently using Computer Algebra System.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	-	-	√	-	-	√	√
CO2	√	-	-	-	-	√	-	-	√	√
CO3	√	-	-	-	-	√	-	-	√	√
CO4	-	-	-	-	-	√	-	-	√	√
CO5	√	-	-	-	-	√	-	-	√	√
CO6	-	-	-	√	-	-	-	-	√	√

Course Title: Introduction to Computer Algebra System
Course Code: UC-MSM-106-18

UNIT-I

The MATLAB environment, scalars, variables, arrays, mathematical operations with arrays, built-in and user defined functions, graphics: two-dimensional and three-dimensional, m-files: script and function files, functions: input; disp and fprintf, relational and logical operators, symbolic math: symbolic objects and expressions; collect; expand; factor; simplify; simple; pretty; solve; diff and int commands, Programming: if-end structure; if-else-end structure; if-elseif-else-end structure; loops: for-end and while-end

UNIT-II

The structure of MATHEMATICA, notebook interfaces, constants, variables, algebraic calculations, four kinds of brackets, lists, tables, expressions, functions, built-in functions, functional operations, graphics, patterns, manipulating lists, transformation rules, evaluation of expressions, modularity, manipulating notebooks, relational and logical operators, symbolic math commands: D; Integrate; Sum; Product; Solve; Eliminate; Reduce; Series; Limit; Minimize; basic numerical mathematics, Programming: conditionals; loops: Do; For and While.

Text and Reference Books:

1. Higham, D.J. and Higham, N.J., MATLAB Guide, 2nd Edition. Society for Industrial and Applied Mathematics (SIAM), 2005.
2. Gilat, A., MATLAB: An Introduction with Applications, 5th Edition. John Wiley & Sons, 2014.
3. Wolfram, S., The MATHEMATICA Book, 5th revised edition. Wolfram Media Inc, 2004.
4. Abell, M. and Braselton, J., Mathematica by Example, 5th Edition. Academic Press, 2017.

SEMESTER-II

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UC-MSM-202-18	Real Analysis-II	L-4, T-1, P-0	4 Credits

Pre-requisite: Calculus of several variables and Real Analysis-I

Course Objectives: This course is designed to consider theoretical foundations of concepts of mathematical analysis, viz. derivative, MVTs, functions of several variables, measure theory and integration that have many important applications in different branches of pure and applied mathematics. Further, the objective is enable students familiar with these concepts and their fruitful applications.

Course Outcomes: At the end of the course, the students will be able to

CO1	Apply the knowledge of concepts of functions of several variables and measure theory in order to study theoretical development of different mathematical concepts and their applications.
CO2	Understand the nature of abstract mathematics and explore the concepts in further details
CO3	Utilize the concepts of derivative, MVTS for vector-valued functions in applications different fields for example management, industry and economics etc.
CO4	Recognize the need of concept of measure from a practical view point.
CO5	Understand measure theory and integration from theoretical point of view and apply its tools in different fields of applications.
CO6	Extend their knowledge of Lebesgue theory of integration by selecting and applying its tools for further research in this and other related areas

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	√	√	-	-	-	√	√
CO2	-	√	-	√	√	-	-	-	√	√
CO3	√	-	-	√	√	-	-	-	√	√
CO4	-	√	-	√	√	-	-	-	√	√
CO5	-	√	-	√	√	-	-	-	√	√
CO6	-	-	-	√	√	-	-	-	√	√

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Course Title: Real Analysis-II

Course Code: UC-MSM-202-18

UNIT-I

Differentiation of Real functions, Mean value theorems, Taylor's theorem, Differentiation of vector-valued functions, Functions of several variables: Linear transformations, Differentiation, Contraction principle, The Inverse function theorem, The implicit function theorem. [Ref. 3]

UNIT-II

Lebesgue Measure: Introduction, Lebesgue outer measure, Measurable sets and Lebesgue measure, non-measurable set, Measurable functions, Borel and Lebesgue measurability, Littlewood's three principles.

UNIT-III

Lebesgue Integral: The Riemann integral, The Lebesgue integral of a bounded function over a set of finite measure, the integral of a nonnegative function, The general Lebesgue integral, Convergence in measure.

UNIT-IV

Differentiation and Integration: Differentiation of monotone functions, The Four derivatives, Functions of bounded variation, differentiation of an integral, Lebesgue Differentiation Theorem. Absolute continuity. Convex Functions.

RECOMMENDED BOOKS:

1. Royden, H.L. and Fitzpatrick, P.M., *Real Analysis, 4th Edition.* New Delhi: Pearson, 2010.
2. Barra, G. de., *Measure Theory and Integration*, New Delhi: Woodhead Publishing, 2011.
3. Rudin, W., *Principles of Mathematical Analysis, 3rd Edition*. New Delhi: McGraw-Hill Inc., 2013.
4. Carothers, N. L., *Real Analysis*, Cambridge University Press, 2000.
5. Apostol, T.M., *Mathematical Analysis –A modern approach to Advanced Calculus*. New Delhi: Narosa Publishing House, 1957.

UC-MSM-203-18	Mechanics-I	L-4, T-1, P-0	4 Credits

Pre-requisite: Basic Mechanics and Calculus of several variables

Course Objectives: To demonstrate knowledge of functional and extremum path and the application of the knowledge in solving some fundamental problems. To demonstrate the knowledge and understanding of the fundamental concepts in the dynamics of system of particles and Lagrangian and Hamiltonian formulation of mechanics. To represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulation of classical mechanics.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the concept of functional and determine stationary paths of a functional to deduce the differential equation for stationary paths.
CO2	Use Euler-Lagrange equation to find stationary paths and its applications in some classical fundamental problems.
CO3	Define and understand basic mechanical concepts related to discrete and continuous mechanical systems.
CO4	describe and understand the motion of a mechanical system using Lagrange-Hamilton formalism.
CO5	Connect concepts and mathematical rigor in order to enhance understanding.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	√	-	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	√	-	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

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Course Title: Mechanics-I

Course Code: UC-MSM-203-18

UNIT-I

Functional and its properties, Variation of a functional, Motivating problems: Brachistochrone, isoperimetric, Geodesics. Fundamental lemma of calculus of variation, Euler's equation for one dependent function of one and several variables. Generalization to n dependent functions and dependence on several derivatives. Invariance of Euler's equation, Moving end points problem, extremum under constraints.

UNIT-II

Constraints, Generalized coordinates, Generalized velocity, Generalized force, Generalized potential, D'Alembert principle, Lagrange's equation of first kind and second kind, uniqueness of solution, Energy equation for conservative field. Examples based on solving Lagrange's equation.

UNIT-III

Legendre transformation, Hamilton canonical equation, cyclic coordinates, Routhian procedure, Poisson bracket, Poisson's identity, Jacobi-Poisson theorem, Hamilton's principle, Principle of Least action, Small oscillations of conservative system, Lagrange's equation for small oscillations, Nature of roots of frequency equation, Principle oscillations. Normal coordinates.

UNIT-IV

Canonical transformations, Hamilton-Jacobi equation. Method of Separation of variables, Lagrange's bracket, Hamilton's equations in Poisson bracket, Canonical character of transformation through Poisson bracket. Invariance of Lagrange's bracket and Poisson's bracket. Action-Angle Variables.

RECOMMENDED BOOKS:

1. Elsegolc, L.D., *Calculus of Variation*, Dover Publication, 2007.
2. Gantmacher, F., *Lectures in Analytic Mechanics,* Moscow: Mir Publisher, 1975.
3. Goldstien, H., Poole, C. and Safco, J.L., *Classical Mechanics, 3rd Edition*. Addison Wesely, 2002.
4. Landau, L.D. and Lipshitz, E.M., *Mechanics,* Oxford: Pergamon Press, 1976.
5. Marsden, J.E., *Lectures on Mechanics*, Cambridge University Press, 1992.
6. Biswas, S. N., *Classical Mechanics*, Books and Applied (P) Ltd., 1999.

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UC-MSM-204-18	**Partial Differential Equations**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Calculus of several variables and ODE

Course Objectives: The Objective of this course is to introduce first and higher order partial differential equations and their classification. This course explains various analytic methods for computing the solutions of various partial differential equations. It also explains various applications of partial differential equations in real physical phenomenon like wave equation of string, diffusion equations and heat flow equation to students.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand partial differential equations of first order (linear and nonlinear), second and higher order.
CO2	Apply various analytic methods for computing solutions of various PDEs.
CO3	Determine integral surfaces passing through a curve, characteristic curves of second order PDE and compatible systems.
CO4	Understand the formation and solution of some significant PDEs like wave equation, heat equation and diffusion equation.
CO5	Apply the knowledge of PDEs and their solutions in order to understand physical phenomena.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	-	√	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

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Course Title: Partial Differential Equations

Course Code: UC-MSM-204-18

UNIT-I

First Order PDE: Partial differential equations; its order and degree; origin of first-order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution.

UNIT-II

Second and Higher Order PDE: Origin of second order PDE; linear second and higher order PDE with constant and variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order.

UNIT-III

Separation of Variable Method: Separation of variables for PDE; wave, diffusion and Laplace equations and their solutions by Separation of variables method; Elementary solutions of Laplace equations.

UNIT-IV

Applications of PDE: Vibrations governed by one and two-dimensional wave equations; vibrations of string and membranes; three dimensional problems; diffusion equation; resolution of boundary value problems for diffusion equations and elementary solutions of diffusion equations.

RECOMMENDED BOOKS:

1. Sneddon, I.N., *Elements of Partial Differential Equation, 3rd Edition.* McGraw Hill Book Company, 1998.
2. Copson, E.T., *Partial Differential Equations, 2nd Edition.* Cambridge University Press, 1995.
3. Strauss, W.A., *Partial Differential Equations: An Introduction, 2nd Edition*. 2007.
4. Sharma, J.N. and Singh, K., *Partial differential equations for engineers and scientists, 2nd Edition*. New Delhi: Narosa Publication House, 2009.

UC-MSM-205-18	Numerical Analysis	L-4, T-1, P-0	4 Credits

Pre-requisite: Basic Calculus, analysis and linear algebra

Course Objectives: This course is designed to introduce the basic concepts of Numerical Mathematics in order to solve the problems arising in various fields of application, for example in science, engineering and economics etc. that do not possess analytical solutions or difficult to deal with analytically. This course addresses development, analysis and application of different numerical methods to solve the problems, viz. system of linear & nonlinear equations, numerical initial and boundary value problems of ordinary differential equations etc.

Course Outcomes: At the end of the course, the students will be able to

CO1	Identity and analyze different types of errors encountered in numerical computing.
CO2	Apply the knowledge of Numerical Mathematics to solve problems efficiently arising in science, engineering and economics etc.
CO3	Utilize the tools of the Numerical Mathematics in order to formulate the real-world problems from the view point of numerical mathematics.
CO4	Design, analyze and implement of numerical methods for solving different types of problems, viz. initial and boundary value problems of ordinary differential equations etc.
CO5	Create, select and apply appropriate numerical techniques with the understanding of their limitations so that any possible modification in these techniques could be carried out in further research.
CO6	Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	-	-	-	√	-	-	-	-	√	√
CO2	√	-	-	-	-	-	-	-	√	√
CO3	√	-	-	-	-	-	-	-	√	√
CO4	√	-	-	-	-	-	-	-	√	√
CO5	√	√	-	-	-	√	-	-	√	√
CO6	-	-	-	√	-	-	-	-	√	√

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Course Title: Numerical Analysis
Course Code: UC-MSM-205-18

UNIT-I

Numerical computation and Error analysis: Numbers and their accuracy, Floating point arithmetic, Errors in numbers, Error estimation, General error formulae, Error propagation in computation. Inverse problem of error analysis and Numerical instability. Algebraic and transcendental equations: Bisection method, Iteration method, Regula-Falsi method, Secant method, Newton-Raphson's method. Convergence of these methods. Lin-Bairstow's method, Muller's method, Graeffe's root squaring method, Solution of system of nonlinear equations, Complex roots by Newton-Raphson's method.

UNIT-II

System of linear algebraic equations: Gauss elimination method without pivoting and with pivoting, Gauss-Jordon method, LU-factorization method, Jacobi and Gauss-Seidal methods, Convergence of iteration methods, Round-off errors and refinement, ill-conditioning, Partitioning method, Inverse of matrices. Eigen values and eigen vectors: Rayleigh Power method, Given's method and Householder's method.

UNIT-III

Interpolation: Finite differences, Newton's interpolation formulae, Gauss, Stirling's and Bessel's formulae, Lagrange's, Hermite's and Newton's divided difference formulae. Numerical differentiation and integration: differentiation at tabulated and non-tabulated points, Maximum and minimum values of tabulated function, Newton-Cotes Formulae-Trapezoidal, Simpson's, Boole's and Weddle' rules of integration with errors, Romberg integration, Gaussian integration, Double integration by Trapezoidal and Simpson's rules.

UNIT-IV

Ordinary differential equations: Taylor series and Picard's methods, Euler's and modified Euler methods, Runge-Kutta methods, Predictor-Corrector methods: Adams-Bashforth's and Milne's methods. Error analysis and accuracy of these methods. Solution of simultaneous and higher order equations, Boundary value problems: Finite difference and Shooting methods.

RECOMMENDED BOOKS:

1. Sharma, J.N., *Numerical Methods for Engineers and Scientists, 2nd Edition*. Narosa Publ. House New Delhi/Alpha Science International Ltd., Oxford UK, 2007, Reprint 2010.
2. Jain, M.K., Iyengar, S.R.K. and Jain, R.K., *Numerical Methods for Scientific and Engineering Computation, 5th Edition. New Age International Publ.* New Delhi, 2010
3. Bradie, B., *A Friendly Introduction to Numerical Analysis*. Pearson Prentice Hall, 2006.
4. Atkinson, K.E., *Introduction to Numerical Analysis, 2nd Edition*. John Wiley, 1989.
5. Scarborough, J.B., *Numerical Mathematical Analysis.* Oxford & IBH Publishing Co., 2001.

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UC-MSM-206-18	Numerical Analysis (Lab)	L-0, T-0, P-3	3 Credits

Pre-requisite: Basic knowledge of Computer programming and Computer Algebra System (CAS): MATLAB or MATHEMATICA

Course Objectives: This course is designed to provide understanding of implementation of basic numerical methods for solving different problems viz. nonlinear equations, system of linear equations, interpolation and extrapolation, numerical differentiation and integration, numerical initial and boundary value problems of ordinary differential equations etc. Further, this course will develop programming skills in the students in order to write and implement their own computer programs for solving problems arising in science, engineering and economics.

Course Outcomes: At the end of the course, the students will be able to

CO1	Apply their knowledge of computer programming to develop and implement their own computer codes of numerical methods for solving different types of complex problems viz. nonlinear equations, system of linear equations, interpolation and extrapolation, numerical differentiation and integration, numerical initial and boundary value problems of ordinary differential equations etc.
CO2	Understand different implementation modes of a numerical method in order to solve a given problem efficiently.
CO3	Analyze and modify computer codes available in the scientific literature.
CO4	Utilize the symbolic tools of Computer Algebra System (CAS) for example MATLAB, MATHEMATICA and MAPLE independently and in their computer codes for solving a given problem.
CO5	Develop, select and apply numerical methods as a computer code with the understanding of their limitations so that they can be implemented in order to get acceptable results.
CO6	Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently using computer codes.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	-	-	-	-	-	-	√	√
CO2	-	√	-	-	-	-	-	-	√	√
CO3	√	√	-	-	-	-	-	-	√	√

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CO4	√	-	-	-	-	-	-	-	√	√
CO5	√	√	-	-	-	-	-	-	√	√
CO6	-	-	-	√	-	-	-	-	√	√

Course Title: Numerical Analysis (LAB)

Course Code: UC-MSM-206-18

The following programs of following methods are to be practiced:

1. To find a real root of an algebraic/ transcendental equation by using Bisection method.
2. To find a real root of an algebraic/ transcendental equation by using Regula-Falsi method.
3. To find a real root of an algebraic/ transcendental equation by using Newton-Raphson method.
4. To find a real root of an algebraic/ transcendental equation by using Iteration method.
5. Implementation of Gauss- Elimination method to solve a system of linear algebraic equations.
6. Implementation of Jacobi's method to solve a system of linear algebraic equations.
7. Implementation of Gauss-Seidel method to solve a system of linear algebraic equations.
8. To find differential coefficients of 1st and 2nd orders using interpolation formulae.
9. To evaluate definite integrals by using Newton - Cotes integral formulae.
10. To evaluate definite integrals by using Gaussian Quadrature.
11. To evaluate double integrals by using Trapezoidal and Simpson method.
12. To compute the solution of ordinary differential equations with Taylor's series method.
13. To compute the solution of ordinary differential equations by using Euler's method.
14. To compute the solution of ordinary differential equations by using Runge -Kutta methods.
15. To compute the solution of ordinary differential equations by using Milne-Simpson method.
16. To compute the solution of Boundary value problems of Ordinary Differential Equations by using Finite Difference method.
17. To compute the solution of Boundary value problems of Ordinary Differential Equations by using Shooting method.

RECOMMENDED BOOKS:

1. Fausett, L.V., *Applied Numerical Analysis using MATLAB, 2nd Edition.* Pearson Prentice Hall, 2007.
2. Mathews, J.H. and Fink, K.D., *Numerical Methods using MATLAB, 4th Edition.* Pearson Prentice Hall, 2004.
3. Balagurusamy, E., Object Oriented Programming with C++. New Delhi: Tata McGraw Hill, 1999.
4. Conte, S.D. and Boor, C.D., *Numerical Analysis*. New York: McGraw Hill, 1990.

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SEMESTER-III

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UC-MSM-301-18	Topology	L-4, T-1, P-0	4 Credits
Pre-requisite: Real Analysis-I			

Course Objectives: The objective of the course on **Topology** is to provide the knowledge of Topological Spaces and their importance. To acquaint students with the concept of Homeomorphism and the topological properties and important mathematical concepts which can be generalized in topological spaces, so that students may learn and appreciate the nature of abstract Mathematics.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the concepts of topological spaces and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space.
CO2	Understand the concept of Bases and Subbases, create new topological spaces by using subspace.
CO3	Understand continuity, compactness, connectedness, homeomorphism and topological properties.
CO4	Understand how points of space are separated by open sets, Housdroff spaces and their importance.
CO5	Understand regular and normal spaces and some important theorems in these spaces.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	√	√	-	-	-	√	√
CO2	√	√	√	√	√	-	-	-	√	√
CO3	√	√	-	√	√	-	-	-	√	√
CO4	√	√	-	√	√	-	-	-	√	√
CO5	√	√	-	√	√	-	-	-	√	√

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Course Title: Topology

Course Code: UC-MSM-301-18

UNIT-I

Introduction topological spaces, closed sets, Closure, Dense subsets, neighborhoods, interior, exterior and boundary, Accumulation points and derived sets.
Bases and subbases, Subspaces and relative Topology, Alternative methods of defining a Topology in terms of Kuratowski closure operator and neighborhood systems.

UNIT-II

Open mappings and closed mappings, Continues functions and homomorphism's, Compactness and local Compactness. One-point compactification, connected and arc-wise connected spaces, Components and Locally connected spaces.

UNIT-III

T0 and T1 spaces, T2 spaces and sequences. Hausdorffness of one-point compactification, Axioms of Countability and Seperability, Equivalence of Separable, second Axiom and Lindel of properties in a metricspaces. Equivalence of compact and countably compact sets in metric spaces.

UNIT-IV

Regular and completely regular, Normal and completely normal spaces. Metric spaces as T2, completely normal and first axiom spaces, Urysohn's Lemma, Tietze Extension Theorem.

BOOKS RECOMMENDED

1. Munkres, J. R., *Topology, a first course*, Prentice-Hall of India Ltd., New Delhi, 2000.
2. Joshi, K. D., *An introduction to general topology, 2nd edition,* Wiley Eastern Ltd., New Delhi, 2002.
3. Simmons, G.F., *Introduction to topology and Modern Analysis*, McGraw Hill Publications, 2017.
4. Kelley, J. L., *General Topology*, Springer Verlag, New York, 1990.
5. Armstrong, M.A., *Basic Topology*, Springer International Ed., 2005.

UC-MSM-302-18	**Number Theory and Cryptography**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Congruences, Number System

Course Objectives: This course is designed to provide students an introduction to classical number theory and enable them to study higher courses in number theory, and to apply the learnt concepts of number theory using public-key cryptography.

Course Outcomes: At the end of the course, the students will be able to

CO1	Apply the knowledge of Number theory and Cryptography to attain a good mathematical maturity and enables to build mathematical thinking and skill.
CO2	Utilize the congruences, Chinese remainder theorem, indices, residue classes, Legendre symbols to solve different related problems.
CO3	Identify and analyze different types of divisibility tests, Euler's theorem, Wilson theorem, Mobius inversion formula to formulate and solve various related problems.
CO4	Design, analyze and implement the concepts of Diophantine equations for solving different types of problems, for example, sum of two and four squares.
CO5	Create, select and apply appropriate number theoretic techniques such as primes, greatest integer functions in Cryptography to use in real life problems.
CO6	Identify the challenging problems in modern mathematics and find their appropriate solutions.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	√	√	-	-	-	√	√
CO2	√	√	-	√	√	-	-	-	√	√
CO3	√	√	√	√	√	-	-	-	√	√
CO4	√	√	-	√	√	-	-	-	√	√
CO5	√	√	-	√	√	-	-	-	√	√
CO6	√	-	√	√	-	-	-	-	√	√

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Course Title: Number Theory and Cryptography
Course Code: UC-MSM-302-18

UNIT-I

Divisibility, Greatest common divisor, Euclidean Algorithm, Least Common Multiplier, divisibility of product of r consecutive integers, The Fundamental Theorem of arithmetic, congruences and its properties, Special divisibility tests, Solvability of linear diophantine equations ($ax + by = c$) and congruence equations ($an \equiv b(mod\ c)$), Chinese remainder theorem.

UNIT-II

Arithmetic functions $\phi(n)$, $d(n)$, $\sigma(n)$, $\mu(n)$, Multiplicative functions, Mobius inversion Formula, Complete residue system, Fermat's little theorem, Wilson's theorem, Euler's theorem, Power residue, order of $a(mod\ m)$, Primitive root, Reduced residue system, Euler's solvability criterion, Lagrange's theorem for the number of incongruent solutions of a polynomial.

UNIT-III

Indices and its properties, The greatest integer function, Legendre's formula, Quadratic residues, Legendre symbol, Gauss's Lemma, Quadratic reciprocity law, perfect numbers, Mersenne primes and Fermat prime numbers. [Ref. 2]

UNIT-IV

Cryptography: some simple cryptosystems, need of the cryptosystems, the idea of public key cryptography, RSA cryptosystem. [Ref. 4]

RECOMMENDED BOOKS:

1. Burton, D.M., *Elementary Number Theory, 7th Edition*. McGraw-Hill Education, 2010.
2. Hardy, G.H. and Wright, E.M., *An introduction to the Theory of Numbers, 4th Edition*. Oxford University Press, 1975.
3. Niven, I., Zuckerman, H.S. and Montgomery, H.L., *Introduction to Theory of Numbers, 5th Edition*. John Wiley & Sons, 1991.
4. Koblitz N., *A Course in Number Theory and Cryptography, Graduate Texts in Mathematics, No.114*. New-York: Springer-Verlag, 1987.
5. Stallings, W., *Cryptography and Network Security, 5th Edition.* Pearson, 2010.

UC-MSM-303-18	**Mathematical Statistics**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Basic Statistics and Calculus of several variables

Course Objectives: The aim of the course is to enable the students with understanding of various types of probability distributions and testing of hypothesis problems. It aims to equip the students with standard concepts of statistical techniques and their utilization.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand and utilize the concept of probability.
CO2	Explain the concept of random variable and its applications.
CO3	Explore the different types of discrete and continuous distributions and their utilization.
CO4	Deal with formulation of hypotheses as per situations and their testing.
CO5	Apply the knowledge of statistical techniques in various experimental and industrial requirements.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	-	√	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

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Course Title: Mathematical Statistics

Course Code: UC-MSM-303-18

Unit I

Classical and axiomatic approach to the theory of probability, additive and multiplicative law of probability, conditional probability and Bayes theorem.Random variable, function of random variable, and their distributions, probability mass function, probability density function, cumulative distribution function.

Unit II

Two dimensional random variables, joint, marginal and conditional distributions, independence of random variables, expectation, conditional expectation, moments, product moments, probability generating functions, moment generating function and its properties. Chebyshev's, Markov, Jenson, Techebyshey's, inequalities, stochastic convergence, central limit theorem. characteristic function and its elementary properties.

Unit III

Study of various discrete and continuous distributions, Binomial, Poisson, Geometric, Hyper geometric, Multinomial. Uniform, Exponential, Normal distributions, Gamma distribution, Cauchy, exponential, Beta and gamma distributions, Bivariate normal distribution and distribution of order statistics and range.

Unit IV

Concept of sampling distribution and its standard error, Derivation of sampling distributions of χ^2, t and F distribution of sample mean and sample variance Testing of hypotheses, fundamental notions important tests based on normal distributions, Tests of significance: tests based on normal distribution, χ^2, t and F statistic. Analysis of variance: One way and two-way classifications.

BOOKS RECOMMENDED:

1. Hogg R. V., McKean J. W. and Craig A. T., *Introduction to Mathematical Statistics*, Pearson, 2005, Sixth Edition.
2. Gupta S. C. and Kapoor V. K., *Fundamentals of Mathematical Statistics, 11th Edition.* Sultan Chand & Sons, 2014.
3. Fisz M., *Probability Theory and Mathematical Statistics, 3rd Edition.* John Wiley & Sons, 1967.
4. Gun A.M., Gupta, M.K. and Dasgupta B., *Fundamentals of Statistics (Vol-I)*, World Press, 2013.
5. Feller W., *An Introduction to Probability Theory and Its Applications (Vol-I), 3rd Edition.* John Wiley & Sons, 2003.

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UC-MSM-304-18	**Functional Analysis**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Real analysis and Linear Algebra

Course Objectives: This course will develop a deeper and rigorous understanding of fundamental concepts of functional analysis, their properties and related theorems.

Course Outcomes: At the end of the course, the students will be able to

CO1	Explain the fundamental concepts of functional analysis and their role in modern mathematics.
CO2	Utilize the concepts of functional analysis, for example continuous and bounded operators, normed spaces, Hilbert spaces and to study the behavior of different mathematical expressions arising in science and engineering.
CO3	Understand and apply fundamental theorems from the theory of normed and Banach spaces including the Hahn-Banach theorem, the open mapping theorem, the closed graph theorem and uniform boundedness theorem.
CO4	Understand the nature of abstract mathematics and explore the concepts in further details.
CO5	Explain the concept of projection on Hilbert and Banach spaces.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	√	√	-	-	-	√	√
CO2	√	√	√	√	√	-	-	-	√	√
CO3	√	√	√	√	√	-	-	-	√	√
CO4	√	√	-	√	√	-	-	-	√	√
CO5	√	√		√	√	-	-	-	√	√

Course Title: Functional Analysis

Course Code: UC-MSM-304-18

UNIT-I

Normed Spaces with examples $l^p, l^\infty, C[a,b]$ etc, Banach Spaces, Incomplete normed spaces, Finite Dimensional Normed Spaces and Subspaces, Equivalent norms, Compactness of Metric/ Normed spaces, Riesz's Lemma for two subspaces of a Normed space.

UNIT-II

Linear Operators- definition and examples, Range and Null space, Inverse Operator, Bounded and Continuous linear operators in a Normed Space, Bounded Linear Functionals in a Normed space with examples, Concept of Reflexive space, Dual basis, Dual spaces with examples.

UNIT-III

Inner Product and Hilbert space, Further properties of Inner product spaces, Projection Theorem, Orthonormal Sets, Representation of functionals on a Hilbert Spaces (Riesz's Lemma and Representation), Hilbert Adjoint Operator, Self-adjoint, Unitary & Normal Operators.

UNIT-IV

Fundamental Theorems for Normed & Banach Spaces: Partially Ordered Set and Zorn's Lemma, Hahn Banach Theorem for Real Vector Spaces, Hahn Banach Theorem for Complex Vector Spaces and Normed Spaces, Uniform Boundedness Theorems (Banach-Steinhaus Theorem), Open Mapping Theorem, Closed Graph Theorem.

RECOMMENDED BOOKS:

1. Kreyzig, E., *Introductory Functional Analysis with Applications*. New York: John Willey and Sons, 1989.
2. Limaye, B. V., *Functional Analysis.* New Delhi: New Age International (P) Ltd, 1996.
3. Simmons, G. F., *Introduction to topology and modern analysis.* New Delhi: Tata McGraw-Hill Education Private Limited, 2012.
4. Nair, M. T., *Functional Analysis-A First Course*. New Delhi: Prentice- Hall of India Private Limited, 2008.
5. Rudin, W., *Functional Analysis,* Tata-McGraw Hill Pub. Co.

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UC-MSM-305-18	Mechanics-II	L-4, T-1, P-0	4 Credits

Pre-requisites: Linear Algebra, Vector Calculus and Basic Mechanics

Course Objectives: The objective of the course on Mechanics-II is to equip the students with the knowledge of Tensors and their applications. To make students understand the notion of continuum and the basic concepts of strain, stretch and rotation and the applications of tensors in understanding these concepts. One of the objectives is to make students understand the applications of Mathematical concepts in real world problems related to Mechanics.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the concept of Tensor and their properties.
CO2	Understand the effect of co-ordinate transformations and visualize the tensor as a linear transformation.
CO3	Understand the conventions like summation convention and comma notations. Also, students shall learn the concepts of tensor calculus.
CO4	Understand continuum hypothesis, spatial an material co-ordinates and their applications.
CO5	Understand the concepts of strain, stretch, rotation and shall be able to apply the knowledge in solving real world problems related to continuum mechanics.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	-	√	√	√	-	-	-	√	√
CO2	√	-	√	√	√	-	-	-	√	√
CO3	√	-	√	√	√	-	-	-	√	√
CO4	√	-	√	√	√	-	-	-	√	√
CO5	√	-	√	√	√	-	-	-	√	√

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Course Title: Mechanics-II

Course Code: UC-MSM-305-18

Unit I

Tensors: Introduction, Range and Summation Conventions, Free and dummy suffixes, results in vector algebra and matrix, the symbol δ_{ij} & ε_{ijk} , Coordinate transformations, cartesian tensors, Properties of tensors, Isotropic tensors, Isotropic tensor of order four, Tensors as linear operators, Transpose of a tensor.

Unit II

Tensor Continued: Symmetric and skew tensors, Dual vector of a skew tensor, Invariants of a tensor, Deviatoric tensors, Eigenvalues and eigenvectors, Polar decomposition

Unit III

Scalar, vector and tensor functions, Comma notation, Gradient of a scalar, divergence and curl of a vector, Gradient of a vector, divergence and curl of a tensor, Integral theorems for vectors and tensors.

Unit IV

Continuum Hypothesis: Notation of a continuum, Configuration of a continuum, Mass and density, Descriptions of motion, Deformation: Material and special coordinates, Deformation gradient tensor, Stretch and rotation, Strain tensors, Strain-displacement relations, Infinitesimal strain tensor, Infinitesimal stretch and rotation, Compatibility conditions., Principal strains, Strain-deviator.

BOOKS RECOMMENDED:

1. Jog, C.S., *Foundations and Applications of Mechanics: Volume-I Continuum Mechanics.* Narosa Publishing House, New delhi.
2. Chandrasekharaiah, D.S. and Lokenath, D., *Continuum Mechanics,* Academic Press, London (Prism Books Pvt. Ltd., Bangalore-India).

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SEMESTER-IV

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UC-MSM-401-18	Differential Geometry	L-4, T-1, P-0	4 Credits
Pre-requisite: Basic calculus and vector calculus			
Course Objectives: The objective of this course is to make students familiar with basic concepts of differential geometry so as to deal with geometry of curves and spaces using the methods of differential calculus.			
Course Outcomes: At the end of the course, the studentts will be able to			

CO1	Understand the basic concepts and results related to space curves, tangents, normals and surfaces.
CO2	Explain the geometry of different types of curves and spaces.
CO3	Explain the physical properties of different curves and spaces.
CO4	Understand principal directions and curvatures, asymptotic lines and then apply their important theorems and results to study various properties of curves and surfaces.
CO5	Utilize Geodesics, it's all related terms, properties and theorems.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	-	√	√	-	-	-	√	√
CO2	√	√	√	√	-	-	-	-	√	√
CO3	√	-	√	√	√	-	√	-	√	√
CO4	√	√	√	√	√	-	√	-	√	√
CO5	√	√	√	√	√	-	√	-	√	√

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Course Title: Differential Geometry

Course Code: UC-MSM-401-18

Unit I

Theory of Space Curves: Tangent, principal normal, bi-normal, curvature and torsion. Serretfrenet formulae, Contact between curves and surfaces. Locus of centre of curvature, spherical curvature, Helices.

Unit II

Spherical indicatrix, Bertrand curves, surfaces, envelopes, edge of regression, developable surfaces, two fundamental forms.

Unit III

Curves on a surface, Conjugate Direction, Principle Directions, Lines of Curvature, Principal Curvatures, Asymptotic Lines. Theorem of Beltrami and Enneper, Mainardi- Codazzi equations.

Unit IV

Geodesics, Differential Equation of Geodesic, torsion of Geodesic, Geodesic Curvature, Clairaut's theorem, Gauss- Bonnet theorem, Joachimsthal's theorem, Geodesic Mapping, Tissot's theorem.

BOOKS RECOMMENDED:

1. Weatherburn, C.E., *Differential Geometry of Three Dimensions*, Cambridge University Press, 2016.
2. Willmore, T.J., *Introduction to Differential Geometry*, Dover Publications Inc., United States, 2012.
3. Bansi Lal, *Differential Geometry, 4th Edition.* Atma Ram & Sons, India, 1976.

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ELECTIVE SUBJECTS

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UC-MSM-501-18	Discrete Mathematics	L-4, T-1, P-0	4 Credits

Pre-requisite: Set Theory, Relations, functions.

Course Objectives: Prepare students to develop mathematical foundations to understand and create mathematical arguments require in learning many mathematics and computer sciences courses. To motivate students how to solve practical problems using discrete mathematics. Also, in this course basic concepts of Graph theory such as Trees, Eulerian Graphs, Matching, Vertex colourings, Edge colourings, Planarity, are introduced.

Course Outcomes: At the end of the course, the students will be able to

CO1	construct mathematical arguments using logical connectives and quantifiers.
CO2	understand how lattices and Boolean algebra are used as tools and mathematical models in the study of networks.
CO3	validate the correctness of an argument using statement and predicate calculus.
CO4	learn how to work with some of the discrete structures which include sets, relations, functions, graphs and recurrence relation.
CO5	understand the concepts Planarity including Euler identity.
CO6	discuss and understand the importance of the concepts Matching's and Colourings'.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO2	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO3	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO4	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO5	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO6	✓	✓	✓	✓	✓	-	-	-	✓	✓

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Course Title: Discrete Mathematics
Course Code: UC-MSM-501-18

Unit-I

Mathematical Logic: Basic logical operations, conditional and bi-conditional statements, tautologies, contradiction, predicate calculus.

Recursion and Recurrence Relations: Polynomial expressions, telescopic form, recursion theorem, closed form expression, generating function, solution of recurrence relation using generating function, recursion.

Unit-II

Lattices and Boolean Algebra: Introduction to Binary relations, equivalence relations and partitions, Partial order relations, Hasse diagram. Lattices as partially ordered sets, properties, lattices as algebraic systems, sub lattices. Boolean algebra as lattices, Boolean identities, sub-algebra, Boolean forms and their equivalence, Applications of Boolean algebra to circuit theory.

Unit-III

Graph Theory: Directed graphs, undirected graphs, paths, circuits, cycles, sub-graphs, induced Sub graphs, degree of vertex, connectivity, planner graph, complete, Eulerian paths and circuits, Trees and Coloring of the graph, Rooted tree, spanning trees, minimal spanning trees, Kruskal's algorithm. Chromatic number, four-color problem (statement only).

Unit-IV

Algebraic Structures: Review of groups, codes and group codes, encoders and decoders, hamming matrices, parity checks, decoding and error correction.

BOOKS RECOMMENDED:

1. Tremblay, J.P. and Manohar, R.P., *Discrete Mathematics with Applications to Computer Science*, Tata McGraw Hill, 2008.
2. Ram, Babu, *Discrete Mathematics*, Pearson Education, 2007.
3. Harary, F., *Graph Theory*, Narosa, 1995
4. Anami, B.S and Madalli, V.S., *Discrete Mathematics*, University Press, 2016.
5. Liu, C.L, *Elements of Discrete Mathematics*, 3rd Edition, Tata McGraw Hill, 2008.
6. Grimaldi, R.P and Ramana, B.V., *Discrete and Combinatorial Mathematics-An Applied Introduction*, Pearson education, 5th Edition, 2004..

UC-MSM-502-18	Coding Theory	L-4, T-1, P-0	4 Credits

Pre-requisite: Linear Algebra, Probability theory

Course Objectives: Coding Theory helps to detects errors in Transmission of messages. In this course we introduce the basic concepts of Coding Theory such as, Double Error-Correcting B.C.H. code, Cyclic codes, The Group of a code, Quadratic residue codes and Bose-Chaudhuri- Hocquenghem codes.

Course Outcomes: At the end of the course, the students will be able to

CO1	understand the concept of Maximum-Likelihood Decoding and Syndrome Decoding.
CO2	analyze Double Error-Correcting B.C.H. code and Finite Fields Polynomials.
CO3	understand Cyclic Codes.
CO4	study the concept of Bose-Chaudhuri-Hocquenghem (*B.C.H.*) Codes and Weight Distributions.
CO5	learn about basic techniques of algebraic coding theory like matrix encoding, polynomial encoding, and decoding by coset leaders etc.
CO6	learn how algebraic coding theory is applicable in real world problems.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO2	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO3	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO4	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO5	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO6	✓	✓	✓	✓	✓		-	-	✓	✓

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Course Title: Coding Theory

Course Code: UC-MSM-502-18

Unit-I

Introduction to Coding Theory: Code words, distance and weight function, Nearest-neighbour decoding principle, Error detection and correction, Matrix encoding techniques, Matrix codes, Group codes, decoding by coset leaders, Generator and parity check matrices, Syndrome decoding procedure, Dual codes.

Unit-II

Linear Codes: Linear codes, Matrix description of linear codes, Equivalence of linear codes, Minimum distance of linear codes, Dual code of a linear code, Weight distribution of the dual code of a binary linear code, Hamming codes.

Unit-III

BCH Codes: Polynomial codes, Finite fields, Minimal and primitive polynomials, Bose-Chaudhuri-Hocquenghem codes.

Unit-IV

Cyclic Codes: Cyclic codes, Algebraic description of cyclic codes, Check polynomial, BCH and Hamming codes as cyclic codes. Maximum distance separable codes, Necessary and sufficient conditions for MDS codes, Weight distribution of MDS codes, An existence problem, Reed-Solomon codes.

BOOKS RECOMMENDED

1. Vermani L R, *Elements of Algebraic Coding Theory*, Chapman and Hall, 1996.
2. Vera P., *Introduction to the Theory of Error Correcting Codes*, John Wiley and Sons, 1998.
3. Roman Steven, *Coding and Information Theory*, Springer Verlag, 1992.
4. Garrett Paul, *The Mathematics of Coding Theory*, Pearson Education, 2004.

UC-MSM-503-18	Operations Research	L-4, T-1, P-0	4 Credits

Pre-requisite: Basic Calculus, analysis and linear algebra

Course Objectives: This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc. The major focus will be on formulation of real world phenomena from its physical considerations and implementation of optimization algorithms for solving these problems.

Course Outcomes: At the end of the course, the students will be able to

CO1	Apply the knowledge of basic optimization techniques in order to get best possible results from a set of several possible solution of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.
CO2	Formulate an optimization problem from its physical consideration.
CO3	Select and implement an appropriate optimization technique keeping in mind its limitations in order to solve a particular optimization problem.
CO4	Understand theoretical foundation and implementation of similar type optimization techniques available in the scientific literature.
CO5	Continue to acquire knowledge and skills of optimization techniques that are appropriate to professional activities
CO6	Extend their knowledge of basic optimization techniques to do interesting research work on these types of optimization techniques.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	-	-	-	-	-	-	-	✓	✓
CO2	-	-	✓	-	-	-	-	-	✓	✓
CO3	✓	✓	-	-	-	-	-	-	✓	✓
CO4	-	✓	-	-	-	-	-	-	✓	✓
CO5	-	-	-	-	-	-	✓	-	✓	✓
CO6	-	-	-	-	✓	-	-	-	✓	✓

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Course Title: Operations Research

Course Code: UC-MSM-503-18

UNIT-I

Formulation of linear programming problem (LPP) -graphical method, Basic Feasible Solution, Extreme Points, Convex set, Convex linear combination, optimal solution of LPP using Simplex, Big-M and two-phase methods, Exceptional cases in LPP i.e., Infeasible, unbounded, alternate and degenerate solutions.

UNIT-II

General Primal-Dual pair, Formulating a dual problem, Weak and strong duality theorems, Complementary slackness theorem, Dual simplex method, Economic interpretation of primal-Dual problems. Sensitivity analysis: change in right hand side of constraints, change in the objective function and coefficient matrix addition and deletion of constraint and variables.

UNIT-III

Initial basic Feasible solution of transportation problem, Balanced and unbalanced transportation problems, Optimal solutions of transportation problem using U-V /MODI methods, Assignment problems; Mathematical formulation of assignment problem, typical assignment problem, the traveling salesman problem, Test for optimality, degeneracy, Project management with critical path method.

UNIT-IV

Concept of convexity and concavity, Maxima and minima of convex functions, Single and multivariate unconstrained problems, constrained programming problems, Kuhn-Tucker conditions for constrained programming problems, Quadratic programming, Wolfe's method.

BOOKS RECOMMENDED

1. Taha, H.A., *Operations Research-An Introduction,* PHI, 2007.
2. Kanti Swarup, Gupta, P.K. and Man Mohan, *Operations Research*, Sultan Chand & Sons, Ninth Edition, 2002.
3. Hillier, F.S. and Lieberman, G.J., *Operations Research, Second Edition,* Holden-Day Inc, USA, 1974.
4. Bazaraa, M.S., Sherali, H.D., Shetty, C.M., *Nonlinear Programming: Theory and Algorithms,* John Wiley and Sons, 1993.
5. Chandra, S., Jayadeva, and Mehra, A., *Numerical Optimization and Applications,* Narosa Publishing House, 2013.

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UC-MSM-504-18	Advanced Number Theory	L-4, T-1, P-0	4 Credits

Pre-requisite: Elementary Number Theory

Course Objectives: This Course helps the students to understand the concept of Partitions and Compositions. In this course we introduce the concepts of various identities like Jacobi's triple product identity, Gollnitz-Gordon identities, Rogers-Ramanujan type identities for n-colour partitions, and their applications. Also, the weak and strong versions of various important theorems.

Course Outcomes: At the end of the course, the student will be able to

CO1	understand the different types of partitions & compositions.
CO2	students will have a working knowledge of the various types of identities
CO3	work with congruence's, solve congruence equations and systems of equations with one and more variables.
CO4	be literate in the language and notation of number theory.
CO5	understand the concept of for n-colour partitions

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO2	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO3	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO4	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO5	✓	✓	✓	✓	✓	-	-	-	✓	✓

Course Title: Advanced Number Theory

Course Code: UC-MSM-504-18

UNIT-I

Partitions, Compositions, Ferrers graphs, Jacobi's triple product identity, Congruence properties of $p(n)$, Rogers-Ramanujan identities, Basic hypergeometric series, q-binomial theorem, Sylvester's theorem (Statement only), Heine's transformation (Statement only).

UNIT-II

Restricted partitions, q-Gauss theorem, Gaussian polynomials, Bailey's lemma (weak version) (Statement only), Rogers lemma, q-Saalschutz's theorem (Statement only), Finite version of q-Saalschutz's theorem.

UNIT-III

Schur's theorem, Gollnitz-Gordon identities, Generalization and various analogues of Rogers-Ramanujan identities, Bailey's lemma (strong version) (Statement only), Watson's q-analogue of Whipple's theorem (Statement only) and its applications in deriving Rogers-Ramanujan identities and Gollnitz-Gordon identities.

UNIT-IV

Rank & Crank of a partition, n-colour partitions, Conjugate and self-conjugate n-colour partitions, Restricted n-colour partitions, Rogers-Ramanujan type identities for n-colour partitions.

RECOMMENDED BOOKS:

1. Agarwal, A.K., Padmavathamma and Subbarao, M.V., *Partition Theory*, Atma Ram & Sons, Chandigarh, 2005.
2. Andrews, G.E., *The Theory of Partitions, Encyclopedia of Mathematics and its Applications* (Addison-Wesley), 1976, Re-issued: Cambridge University Press, Cambridge, 1988.
3. Gasper, G. and Rahman, M., *Basic Hypergeometric Series, Encyclopedia of Mathematics and its Applications,* Vol. 35, Cambridge University Press, Cambridge, 1990.
4. Agarwal, R.P., *Resonance of Ramanujan Mathematics,* Vol. 1 (New Age International), 1996.
5. Gupta, H., *Selected Topics in Number Theory*, ABACUS Press, 1980.
6. N.J. Fine, *Basic Hypergeometric Series and Applications*, Mathematical Surveys and Monographs, No. 27, American Mathematical Society, 1988.

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UC-MSM-505-18	**Advanced Complex Analysis**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Complex Analysis, Real Analysis			
Course Objectives: This course is designed to enable the readers to understand further deeper topics of Complex Analysis and will provide basic topics needed for students to pursue research in pure Mathematics.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	equip with necessary knowledge and skills to enable them handle mathematical operations, analyses and problem solving involving complex numbers.
CO2	understanding of topological and geometric properties of the complex plane
CO3	analyze how complex numbers provide a satisfying extension of the real numbers
CO4	learn techniques of complex analysis that make practical problems easy (e.g. graphical rotation and scaling as an example of complex multiplication);
CO5	continue to develop proof techniques.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO2	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO3	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO4	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO5	✓	✓	✓	✓	✓	-	-	-	✓	✓

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Course Title: Advanced Complex Analysis

Course Code: UC-MSM-505-18

Unit-I

Analytic continuation, Analytic continuation by power series method, Natural boundary, Schwarz reflection principle, Analytic continuation along a path, Monodromy theorem, Runge's theorem, simple connectedness, Mittag-Leffler's theorem.

Unit-II

Maximum principle, Schwarz's Lemma, Hadamard's three circle theorem, Phragmen-Lindelof theorem, Weierstrass factorization theorem, Factorization of sine function, Gamma function. Entire functions, Jensen's formula, the genus and order of an entire function, Hadamard factorization theorem.

Unit-III

Harmonic functions, Basic properties, Harmonic functions on a disc, Subharmonic and Superharmonic functions, The Dirichlet problem, Green's function.

Unit-IV

Normal families of analytic functions, Montel's theorem, Hurwitz's theorem, Riemann mapping theorem, Univalent function, Distortion and Growth theorem for the class of normalized univalent functions, Covering theorem, starlike functions, convex functions, Subordination principle.

BOOKS RECOMMENDED

1. Nihari, Z., Conformal Mapping, Conformal Mapping, McGraw-Hill,1952.
2. Conway, J.B., Functions of One Complex Variable, Springer-Verlag,1973
3. Gamelin, T.W., Complex Analysis, Springer, 2004.
4. Tutschke, W. and Vasudeva, H.L., An Introduction to Complex Analysis- Classical and Modern Approaches, Chapman & Hall/CRC, 2005
5. Copson, E.T., An Introduction to Theory of Functions of a Complex Variable.

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UC-MSM-506-18	Advanced Operations Research	L-4, T-1, P-0	4 Credits

Pre-requisite: Basic Calculus, analysis, linear algebra and operations research.

Course Objectives: This course is designed to provide a theoretical introduction and implementation of advanced optimization techniques in order to get best results from a set of several possible solutions of different problems viz. advanced linear programming problem, goal programming problem, game theory, dynamic programming and inventory models. The major focus of this course will be on formulation of real-world phenomena from its physical consideration and implementation of optimization techniques for solving these problems.

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply the knowledge of advanced optimization techniques in order to get best possible results from a set of several possible solutions of a given problem.
CO2	Formulate an optimization problem from its physical considerations.
CO3	Select and implement an appropriate optimization technique keeping in mind its limitations in order to solve a particular optimization problem.
CO4	Understand and analyze similar types of other optimization techniques available in the scientific literature.
CO5	Continue to acquire knowledge and skills of optimization techniques that are appropriate to professional activities.
CO6	Extend their knowledge of advanced optimization techniques in order to do interesting research work on these and similar types of optimization techniques.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	-	-	-	-	-	-	-	✓	✓
CO2	-	-	✓	-	-	-	-	-	✓	✓
CO3	✓	✓	-	-	-	-	-	-	✓	✓
CO4	-	✓	-	-	-	-	-	-	✓	✓
CO5	-	-	-	-	-	-	✓	-	✓	✓
CO6	-	-	-	-	✓	-	-	-	✓	✓

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Course Title: Advanced Operations Research

Course Code: UC-MSM-506-18

Unit I

Advanced Linear Programming: Revised simplex method, Sensitivity analysis, Parametric programming, Integer programming branch and bond algorithm, Goal programming, Standard form of LGPP, Partitioning algorithm.

Unit II

Game Theory: Two-person zero sum games pure strategies (minmax and maximum principles), Game with saddle point, Mixed strategies: Game without saddle point, Rule of Dominance, Solution methods for games without saddle point: Graphical method, Linear programming method.

Unit III

Dynamic Programming: Characteristics of dynamic programming, Recursive relations, continuous and discrete cases, forward recursion, linear programming versus dynamic programming, Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.

Unit IV

Inventory Models: Deterministic models: Classic EOQ (Economic order quantity) models, EOQ with price brakes, Multi item EOQ with storage limitation, Dynamic EOQ models(b) Probabilistic models: Probabilistic EOQ models, Single period models and multiperiod models.

Books Recommended

1. Taha, H.A., *Operations Research- An introduction*, 8th Edition, PHI, 2007.
2. Sharma, J.K, *Operation research: Theory & Applications*, 3rd Edition, Macmillan India, 2007.
3. Kasana, H.S and Kumar K.D, *Introductory Operations Research: Theory & Applications*, Springer, 2005.
4. Pant, J.C, Introduction to Optimization and Operations Research, Jain Brothers, 2004.

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UC-MSM-507-18	**Advanced Fluid Mechanics**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Fluid Mechanics and Continuum Mechanics			
Course Objectives: This course is intended to provide a treatment of advanced topics in fluid mechanics where the students will be able to apply the techniques used in deriving arrange of important results and in research problems. The objective is to provide the student with knowledge of the fluid mechanics and an appreciation of their application to real world problems.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Understand the concept of rotational and irrotational flow, stream functions, velocity potential, sink, source, vortex etc.
CO2	analyze simple fluid flow problems (flow between parallel plates, flow through pipe etc.) with Navier-Stoke's equation of motion.
CO3	understand the phenomenon of flow separation and boundary layer theory
CO4	understand the concept of thermal conductivity.
CO5	learn about the fundamental equations of the flow and energy

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	-	✓	✓	✓	-	-	-	✓	✓
CO2	✓	-	✓	✓	✓	-	-	-	✓	✓
CO3	✓	-	✓	✓	✓	-	-	-	✓	✓
CO4	✓	-	✓	✓	✓	-	-	-	✓	✓
CO5	✓	-	✓	✓	✓	-	-	-	✓	✓

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Course Title: Advanced Fluid Mechanics

Course Code: UC-MSM-507-18

UNIT-I

Basic Concepts: Continuum Hypothesis, Viscosity, Most general motion of a fluid element, Rate of strain quadric, stress at a point, Tensor character of stress matrix, Symmetry of stress matrix, stress quadric, Stress in a fluid at rest, stress in a fluid in motion, Relation between stress and rate of strain components (Stoke's law of friction), Thermal conductivity, Generalized law of heat conduction, Fundamental equations of the flow of viscous fluids: Equation of state, equation of continuity - Conservation of mass, Equation of motion- Navier-Stoke's equations, Equation of energy-Conservation of energy, Symmetry of fundamental equations, Vorticity and circulation in a viscous incompressible fluid motion, (a) velocity transport equation, Circulation

UNIT-II

Dynamical similarity and Dynamical Analysis: Dynamical similarity, Reynold's law, Inspection analysis, Dimensional analysis, Buckingham π-theorem. Method of finding out the pi-products, Application of pi- theorem to viscous and compressible fluid. Physical importance of non-dimensional parameters. Reynolds number, Eckert Number, Froude Number, Mach Number, Pecklet Number, Grashoff Number, Prandtl Number, Brinkman Number, Nussel Number. Exact Solution of Navier-Stoke's equations of motion- Flow between parallel plates (Velocity and temperature distributions), (i) Plane Couette flows (ii) Plane Poiseulle Flow and (iii) Generalized Couette flow.

UNIT-III

Flow in a circular pipe (Hagen Poiseuille flow) -Velocity and temperature distribution, Flow through tubes of uniform cross section in the form of circle, annulus, ellipse and equilateral triangle under constant pressure gradient. Flow between two concentric rotating cylinders (Couette flow), Flow in convergent and divergent channels,

UNIT-IV

Steady incompressible flow with variable viscosity: Variable viscosity plane Couette flow and plane poiseulle flow. Unsteady incompressible flow with constant fluid properties: Flow due to a plane wall suddenly set in motion, flow due to an oscillating plane wall, starting flow in plane Couette motion, Starting flow in pipes, Plane coquette flow with transpiration cooling.

Books Recommended

1. Bansal, J L, *Viscous Fluid Dynamics*, OXFORD & IBH Publishing Company Pvt. Ltd., New Delhi, 1992.
2. Chorlton, F., *Textbook of Fluid Dynamics*, C.B.S. Publishers, Delhi, 1985.
3. Schlichting, H., *Boundary Layer Theory*, McGraw Hill Book Company, New York, 1979.
4. Young, A. D., *Boundary Layers*, AIAA Education Series, Washington DC, 1989.
5. Yuan, S.W., *Foundations of Fluid Mechanics*, Prentice Hall of India Private Limited, New Delhi, 1976

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UC-MSM-508-18	Advanced Solid Mechanics	L-4, T-1, P-0	4 Credits

Pre-requisite: Mechanics-I and Continuum Mechanics

Course Objectives: The primary course objective is to solve advanced solid mechanics problems using classical methods and equip the students with the tools necessary to solve mechanics problems, which involves (a) static analysis of a component to find the internal actions (forces and moments), and determine stresses, strains and deformation due to internal actions.

Course Outcomes: At the end of the course, the students will be able to

CO1	understand the theory of elasticity including strain/displacement and Hooke's law relationships.
CO2	analyze solid mechanics problems using classical methods and energy methods.
CO3	solve for stresses and deflections of beams under unsymmetrical loading.
CO4	obtain stresses and deflections of beams on elastic foundations.
CO5	solve torsion problems in bars and thin walled members.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	-	✓	✓	✓	-	-	-	-	✓
CO2	✓	-	✓	✓	✓	-	-	-	-	✓
CO3	✓	-	✓	✓	✓	-	-	-	-	✓
CO4	✓	-	✓	✓	✓	-	-	-	-	✓
CO5	✓	-	✓	✓	✓	-	-	-	-	✓

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Course Title: Advanced Solid Mechanics

Course Code: UC-MSM-508-18

Unit-I

Basics and Extension of Beams: Hooke's law, generalized Hooke's law, Elastic moduli and their relationship, strain-energy density function and its connection with Hooke's law, Saint-Venant's principle. Extension of beams: extension of beams by longitudinal forces, beam stretched by its own weight and bending of beams by terminal couples.

Unit-II

Torsion and flexure of beams: Torsion of a circular shaft, cylindrical bars, and elliptic cylinder. Stress function, conformal mapping, solution of torsion problem by conformal mapping. Flexure of beams by terminal loads, bending of rectangular beams.

Unit-III

Two-and Three-dimensional Problems: Plane deformation, plane stress, plane elastostatic problems, Airy's stress function, solution of the bi-harmonic equation, stress and displacement formulae basic problems of circular region: uniform pressure, uniform radial displacement and concentrated loads. Spherical shell under external and internal pressures.

Unit-IV

Thermoelastic problems and Variational Methods: Thermal stresses in spherical bodies, two-dimensional thermoelastic problems. Variational methods: Theorems of potential energy, minimum complementary energy, work and reciprocity, Ritz method for one- and two-dimensional problems and Galerkin's method. Kantorovich and Trefftz methods. Application of Treffz method.

Books Recommended

1. Sokolnikoff, I.S., *Mathematical Theory of Elasticity*, TMH, New Delhi 1978.
2. Timoshenko.S. and Young D.H., *Elements of strength of materials Vol. I & Vol. II*, T. Van Nostrand Co-Inc Princeton, N.J., 1990.
3. Love, A.E.H, *A Treatise on the Mathematical theory of Elasticity,* Cambridge University Press, 1963.

UC-MSM-509-18	**Theory of Linear Operators**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Real Analysis, Topology, Integral Equations

Course Objectives: To teach the fundamentals of Banach Algebras and Spectral Operator Theory which are necessary for a deeper understanding of many adjacent mathematical fields (integral and differential equations, mathematical physics, harmonic analysis, operator theory etc.)

Course Outcomes: At the end of the course, the students will be able to

CO1	have understanding of main topics of Banach Algebras and Spectral Theory.
CO2	terminology, notation and the basic results and concepts of Banach and Hilbert spaces.
CO3	understand the concept of spectrum and resolvent, adjoint operators, compact operators, self-adjoint and normal operators, Gelfand Representation, Riesz-Fredholm Theory.
CO4	relation of the subject with other branches of mathematics (Fourier analysis, complex functions, differential equations)
CO5	prepare the students for reading the literature of a wide variety of subjects in which Hilbert space ideas are used.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	-	✓	✓	-	-	-	-	✓
CO2	✓	✓	-	✓	✓	-	-	-	-	✓
CO3	✓	✓	-	✓	✓	-	-	-	-	✓
CO4	✓	✓	✓	✓	✓	-	-	-	-	✓
CO5	✓	✓	-	✓	✓	-	-	-	-	✓

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Course Title: Theory of Linear Operators

Course Code: UC-MSM-509-18

Unit I

Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators. Properties of resolvent and spectrum. Spectral mapping theorem for polynomials.

Unit II

Elementary theory banach algebra, Spectral radius of a bounded linear operator on a complex banach space.

Unit III

General properties of compact linear operators. Spectral properties of compact linear operators on normed spaces. Behaviors of compact linear operators with respect to solvability of operator equations. Fredholm type theorems. Fredholm alternative theorem. Fredholm alternative for integral equations.

Unit IV

Spectral properties of bounded self-adjoint linear operators on a complex Hilbert space. Positive operators. Monotone Sequences theorem for bounded self-adjoint operators on a complex Hilbert space, Square roots of a positive operator.

Books Recommended

1. Kreyszig E., *Introductory functional analysis with applications,* Johan-Wiley & Sons, New York, 1978.
2. Halmos P.R., *Introduction to Hilbert space and the theory of spectral multiplicity*, 2nd Edition. Chelsea Pub., Co., N.Y. 1957.
3. Dunford N. and Schwartz, J.T., *Linear operators-3 parts*, Inter-science Wiley, New York, 1958-71.
4. Bachman G. and Narici, L., *Functional analysis*, Academic Press, New York, 1998.

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UC-MSM-510-18	Advanced Numerical Methods	L-4, T-1, P-0	4 Credits

Pre-requisite: Basic Calculus and analysis. Basic numerical analysis

Course Objectives: This course is designed to provide a theoretical introduction and application of advanced numerical methods for solving different types of problems viz. linear systems, eigenvalues problems, ordinary and partial differential equations arising in various field of applications, for example in science, engineering and economics etc. The major focus will be on development, analysis and implementation of numerical methods keeping in mind advantages & limitations of these methods.

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply the knowledge of advanced numerical methods in order to solve different types of problems viz. linear systems, eigenvalues problems, ordinary and partial differential equation arising in various field of applications for example in science, engineering and economics etc.
CO2	Understand advantages and limitations of advanced numerical methods.
CO3	Select and implement an appropriate numerical method for solving a given problem keeping in mind nature of the problem.
CO4	Use theoretical basis of these methods in order to study their counterparts existing in the scientific literature.
CO5	Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently.
CO6	Extend their knowledge to do research work on these methods and similar type of other methods.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	-	-	-	-	-	-	-	✓	✓
CO2	-	✓	-	-	-	-	-	-	✓	✓
CO3	✓	✓	-	-	-	-	-	-	✓	✓
CO4	-	✓	-	-	-	-	-	-	✓	✓
CO5	-	-	-	✓	-	-	-	-	✓	✓
CO6	-	-	-	-	✓	-	-	-	✓	✓

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Course Title: Advanced Numerical Methods
Course Code: UC-MSM-510-18

Unit-I

Iterative Methods for Linear Systems & Eigenvalue problem: The classical iterative methods: Jacobi, Gauss-Seidel and Successive Over Relaxation (SOR) methods. Conjugate gradient method. Eigenvalues & eigenvectors: Rayleigh power method & Givens method.

Unit-II

Finite Difference Methods: Explicit and implicit schemes, consistency, stability and convergence, Lax equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

Unit-III

Approximate methods of solution: Rayleigh-Ritz, collocation and Galerkin methods, properties of Galerkin approximations, Petrov-Galerkin method, Generalized Galerkin method.

Unit-IV

Finite Element Method (FEM): FEM for second order problems, One- and two-dimensional problems, The finite elements (elements with a triangular mesh and a rectangular mesh and three-dimensional finite elements), Fourth-order problems, Hermite families of elements, iso-parametric elements, numerical integration.

BOOKS RECOMMENDED:

1. Jain, M.K, Iyengar, S.R.K. and Jain, R.K., *Numerical Methods for Scientific and Engineering Computation*, 5^{th} Edition, New Age international, 2008.
2. Hoffman Joe D., *Numerical methods for Engineers and Scientists*, McGrow-Hill, 1993.
3. Atkinson, K.E, *An Introduction to Numerical Analysis,* 2^{nd} Edition, *John Wiley*, 2004.
4. Gupta R.S., *Elements of Numerical Analysis*, McMillan India, 2009
5. Seshu P., *Textbook of Finite Element Analysis*, Prentice Hall India, 2003.

UC-MSM-511-18	Topological Vector Spaces	L-4, T-1, P-0	4 Credits

Pre-requisite: Linear Algebra, Real Analysis, Topology

Course Objectives: The aim of this course is to give an overview of the most important concepts and results of the theory of topological vector spaces (TVS). As the name suggests, this theory beautifully connects topological and algebraic structures. The main focus will be the study of TVS over the reals and particular attention will be given to locally convex spaces (e.g. normed, seminormed and nuclear spaces).

Course Outcomes: At the end of the course, the student will be able to

CO1	understand the general theory of topological vector spaces.
CO2	learn the basic properties of topological vector spaces.
CO3	define the structure of locally-convex topological vector spaces.
CO4	understanding and analyzing inductive and projective limits.
CO5	understand the structure of, Frechet spaces, Montel, Schwartz, and nuclear spaces.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO2	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO3	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO4	✓	✓	✓	✓	✓	-	-	-	✓	✓
CO5	✓	✓	✓	✓	✓	-	-	-	✓	✓

Course Title: Topological Vector Spaces

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Course Title: Topological Vector Spaces
Course Code: UC-MSM-511-18

Unit-I

Review of basic concepts of topological spaces and vector spaces. Prodect topological spaces, projection maps, compactness of prodect topological spaces-Tichonov's theorem.

Topological vector spaces (TVSs), examples of TVSs, Normed vector spaces as TVSs, Translation and multiplication maps, Neighborhood of 0, separated TVS, linear maps between TVSs, Bounded subsets of a topological vector space.

Unit-II

Locally convex topological spaces, normable and metrizable topological vector spaces, complete topological vector spaces

Unit-III

Frechet spaces, Uniform boundedness principle, open mapping and closed graph theorems for Frechet spaces.

Unit-IV

Banach-Alaoglu theorem, Variational inequalities, Lion-Stampacchia theory, Physical phenomenon represented by variational inequalities, points and external sets-Krein Miliman theorem.

BOOKS RECOMMENDED:

1. Munkres J. R., *Topology – A First Course*, Prentice-Hall of India, 1978.
2. Kelley, J.L., *Linear topological spaces*, Van Nostrand East West Press, New Delhi.
3. Wilansky A., *Modern Methods in Topological Vector Spaces,* McGraw Hill, 1978.
4. Simmons G. F., *Introduction to Topology and Modern Analysis*, McGraw-Hill, 1963.
5. Rudin W., *Functional Analysis*, 2nd Edition, McGraw Hill, 1973.

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UC-MSM-512-18	Fractional Calculus	L-4, T-1, P-0	4 Credits

Pre-requisite: Differential Equations (Ordinary and Partial), Mathematical Methods

Course Objectives: The objective of this course to cover the basics of the fractional calculus, or more aptly called the calculus of derivatives and integrals to an arbitrary order. Then introduce the concept of fractional differential equations and consider some of their applications. Also, study the numerical solution of fractional differential equations

Course Outcomes: At the end of the course, the studenst will be able to

CO1	understand the Riemann-Liouville fractional integral and evaluate fractional integrals of some common functions
CO2	define the Riemann-Liouville and Caputo fractional derivatives and find the fractional derivatives of some common functions
CO3	state sufficient conditions under which the fractional integrals and derivatives exist
CO4	investigate some applications of the fractional calculus to the real world.
CO5	solve linear fractional differential equations using the Laplace transform and Fourier Transforms

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	-	✓		✓	-	-	-	-	✓
CO2	✓	-	✓		✓	-	-	-	-	✓
CO3	✓	-	✓		✓	-	-	-	-	✓
CO4	✓	-	✓	✓	✓	-	-	-	-	✓
CO5	✓	-	✓		✓	-	-	-	-	✓

Course Title: Fractional Calculus

Course Code: UC-MSM-512-18

Unit-I

Special Functions of the Fractional Calculus. Gamma Function. Mittag-Leffler function, Fractional Derivatives and Integrals. Grunwald-Letnikov Fractional Derivatives. Riemann Liouville Fractional Derivatives. Some Other Approaches.

Unit-II

Geometric and Physical Interpretation of Fractional Integration and Fractional Differentiation. Sequential Fractional Derivatives. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives. Fourier Transforms of Fractional Derivatives. Mellin Transforms of Fractional Derivatives.

Unit-III

Linear Fractional Differential Equations. Fractional Differential Equation of a General Form. Existence and Uniqueness Theorem as a Method of Solution. Dependence of a Solution on Initial Conditions. The Laplace Transform Method. Standard Fractional Differential Equations. Sequential Fractional Differential Equations. Fractional Green's Function. Definition and Some Properties. One-Term Equation. Two Term Equation. Three-Term Equation. Four-Term Equation. General Case: n-term Equation.

Unit-IV

Other Methods for the Solution of Fractional-order Equations. The Mellin Transform Method. Power Series Method. Babenko's Symbolic Calculus Method. Method of Orthogonal Polynomials. Numerical Evaluation of Fractional Derivatives. Approximation of Fractional Derivatives. Order of Approximation. Computation of Coefficients. Higher-order Approximations.

Books Recommended

1. Podlubny, I., *Matrix approach to discrete fractional calculus vol. 3*, Fractional Calculus and Applied Analysis, 2000.
2. Carpinteri A, Mainardi F, editors. *Fractals and fractional calculus in continuum mechanics,* New York, Springer-Verlag Wien, 1997.
3. Mandelbrot B.B., *The fractal geometry of nature,* New York, W. H. Freeman, 2000.
4. Miller K.S., Ross B., *An introduction to the fractional calculus*. New York, John Wiley, 1993.
5. Oldham KB, Spanier J., *The fractional calculus,* New York, Academic Press, 1974.

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Scheme of the Program:

SEMESTER FIRST **Contact Hrs. 34 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-101-19	Calculus -I	4	1	-	40	60	100	4
2.	UC-BSHM-102-19	Co-ordinate Geometry	4	1	-	40	60	100	4
3.	UC-BSHM-103-19	Programming Lab-I	-	-	4	30	20	50	2
4.*	UC-BSHP-112-19	Electricity and Magnetism	3	1	-	40	60	100	4
	UC-BSHP-113-19	Physics Lab-I	-	-	4	30	20	50	2
	UGCA-1902	Fundamentals of Computer and IT	3	1	-	40	60	100	4
	UGCA-1906	Fundamentals of Computer and IT Laboratory	-	-	4	60	40	100	2
5.**	UC-BHCL-I-101-19	Inorganic Chemistry	3	1	-	40	60	100	4
	UC-BHCP-I-102-19	Chemistry Lab-I	-	-	4	30	20	50	2
	BBA-GE 101	Managerial Economics-I	5	1	0	40	60	100	6
6.	UC-BSHL-105-19	Communicative English -I	2	-	-	20	30	50	2
7.	UC-BSHL-106A/106B-19	Punjabi Compulsory-I/ Mudhli Punjabi-I	2	-	-	20	30	50	2
		Total							26

L:Lectures T: Tutorial P:Practical Cr: Credits

Note 1*: Physics (UC-BSHP-112-19 & UC-BSHP-113-19) and Chemistry (UC-BHCL I-101-19 & UC-BHSP-I-102-19) are compulsory for the Students with Non-Medical background.

Note 2: Students without Non-medical background may opt Fundamentals of Computer and IT (UGCA-1902 & UGCA-1906) and Managerial Economics-I (BBA-GE-101).**

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SEMESTER SECOND

Contact Hrs. 34 Hrs.

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-201-19	Calculus-II	4	1	-	40	60	100	4
2.	UC-BSHM-202-19	Solid Geometry	4	1	-	40	60	100	4
3.	UC-BSHM-203-19	Programming Lab-II	-	-	4	30	20	50	2
4.*	UC-BSHP-124-19	Waves and Vibrations	3	1	-	40	60	100	4
	UC-BSHP-125-19	Physics Lab-II	-	-	4	30	20	50	2
	UGCA-1909	Object Oriented Programming using C++	3	1	-	40	60	100	4
	UGCA-1910	Object Oriented Programming using C++ Laboratory	-	-	4	60	40	100	2
5.**	UC-BHCL-113-19	Organic Chemistry	3	1	-	40	60	100	4
	UC-BHCP-119-19	Chemistry Lab-II	-	-	4	30	20	50	2
	BBA-GE 201-18	Managerial Economics-II	5	1	0	40	60	100	6
6.	UC-BHHL-115-19	Communicative English -II	2	-	-	20	30	50	2
7.	UC-BHHL-116A/116B-19	Punjabi Compulsory-II/ Mudhli Punjabi-II	2	-	-	20	30	50	2
		Total							26

L:Lectures T: Tutorial P:Practical Cr: Credits

Note 1*: Physics (UC-BSHP-112-19 & UC-BSHP-113-19) and Chemistry (UC-BHCL-113-19 & UC-BHCP-119-19) are compulsory for the Students with Non-Medical background.

Note 2: Students without Non-medical background may opt Object Oriented Programming using C++ (UGCA-1909 & UGCA-1910) and Managerial Economics-II (BBA-GE-201)**

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Scheme of the Program:

SEMESTER THIRD **Contact Hrs. 34 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-301-19	Calculus -III	4	1	-	40	60	100	4
2.	UC-BSHM-302-19	Real Analysis-I	4	1	-	40	60	100	4
3.	UC-BSHM-303-19	Algebra-I	-	-	4	40	60	100	4
4.	UC-BSHM-304-19	Programming Lab-III	-	-	4	30	20	50	2
5.*	UC-BSHP-214-19	Elements of Modern Physics	3	1	-	40	60	100	4
	UC-BSHP-215-19	Physics Lab-III	-	-	4	30	20	50	2
	UGCA1914	Programming in Python	3	1	-	40	60	100	4
	UGCA-1917	Programming in Python Laboratory	-	-	4	60	40	100	2
6.**	UC-BHCL-I-204-19	Physical Chemistry	3	1	-	40	60	100	4
	UC-BHCP-I-208-19	Chemistry Lab-III	-	-	4	30	20	50	2
	BBA-301-18	Organizational Behavior	5	1	0	40	60	100	6
		Total							26

L:Lectures T: Tutorial P:Practical Cr: Credits

Note 1*: Physics (UC-BSHP-214-19 & UC-BSHP-215-19) and Chemistry (UC-BHCL I-204-19 & UC-BHSP-I-208-19) are compulsory for the Students with Non-Medical background.

Note 2: Students without Non-medical background may opt Programming in Python(UGCA-1914 & UGCA-1917) and Organizational Behavior (BBA-GE-301-18).**

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SEMESTER FOURTH

Contact Hrs. 34 Hrs.

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-401-19	Vector Calculus	4	1	-	40	60	100	4
2.	UC-BSHM-402-19	Ordinary Differential Equations	4	1	-	40	60	100	4
3.	UC-BSHM-403-19	Linear Algebra	4	1	-	40	60	100	4
4.	UC-BSHM-404-19	Probability and Statistics	4	1	-	40	60	100	4
5.	UC-BSHM-405-19	Programming Lab-IV	-	-	4	30	20	50	2
6.	UC-BSHM-406-19	Project Work	6	-	-	40	60	100	6
7.	UC-BSHM-407-19	Skill Enhancement Course (Audit)	2	-	-	-	-	-	-
8.	EVS-101A	Environmental Studies	2	-	-	40	60	100	2
Total									26

L:Lectures T: Tutorial P:Practical Cr: Credits

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Semester Fifth

Contact Hour: 28

S. No	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-501-19	Real Analysis-II	4	1	-	40	60	100	4
2.	UC-BSHM-502-19	Algebra-II	4	1	-	40	60	100	4
3.	UC-BSHM-503-19	Numerical Methods	4	1	-	40	60	100	4
4.	UC-BSHM-504-19	Partial Differential Equations	4	1	-	40	60	100	4
5.	UC-BSHM-505-19	Project Work	-	-	8	60	40	100	4

L: Lectures **T: Tutorials** **P: Practical**

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Semester Sixth **Contact Hours: 25**

S. No	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-601-19	Number Theory	4	1	-	40	60	100	4
2.	UC-BSHM-602-19	Complex Analysis	4	1	-	40	60	100	4
3.	UC-BSHM-603-19	Mechanics	4	1	-	40	60	100	4
4.	UC-BSHM-604-19	Discrete Mathematics	4	1	-	40	60	100	4
5.	UC-BSHM-605-19	Integral Equations and Integral Transforms	4	1	-	40	60	100	4

L: Lectures **T: Tutorials** **P: Practical**

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B.Sc. (Hons.) Mathematics

Course Structure and Syllabus

University Campus

(Based on Choice Based Credit System)

2019 onwards

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SEMESTER-I

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UC-BSHM-101-19	Calculus-I	L-4, T-1, P-0	4 Credits

Pre-requisite: Elementary calculus of senior secondary level.

Course Objectives: The objectives of this course are to make the students understand the following:

1. The fundamental concepts of differential and integral calculus.
2. The geometrical meaning of functions, limits, continuity, derivatives, mean value theorems.
3. Applications of derivatives and sketching of curves.
4. The definition of Integral calculus and its basic applications.
5. The relation between derivative and the integration of a function.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the basic concepts of Differential and Integral Calculus.
CO2	Visualize all concepts geometrically.
CO3	Sketch curves of the functions intuitively with the help of Differential Calculus.
CO4	Apply the knowledge of Differential and Integral Calculus.
CO5	Understand the fundamental relation between differential and Integral Calculus.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	3	3	2	2	3
CO2	3	2	2	2	3
CO3	3	2	2	2	3
CO4	2	3	2	2	3
CO5	3	2	2	2	3

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Course Title: Calculus-I
Course Code: UC-BSHM-101-19

UNIT-I

Real line, intervals, order properties of real numbers, the least upper bound and the greatest lower bound properties, Archimedean property. Functions, Graphs of functions, Exponential functions, Inverse functions and Logarithmic functions, implicitly defined functions, some special functions, one-one functions, onto functions, composition of functions, limit of a function, calculating limits through limit laws, The precise definition of limit (ε-δ definition), continuity, limit at infinity, asymptotes, continuous functions and classification of discontinuities, uniform continuity.

UNIT-II

Derivative of a function, the derivative as a function, derivatives of polynomials and exponential functions, the product and quotient rules, rates of change in natural and social sciences, derivatives of trigonometric, inverse trigonometric, logarithmic and hyperbolic functions, the chain rule, implicit differentiation, higher derivatives, preliminary transformations, differentiation of determinants.

UNIT-III

Application of derivative: maximum and minimum values, increasing and decreasing functions, mean value theorems, Intermediate value theorems, How derivatives affect the shape of graph, L' Hospital's rule, concavity and convexity, the second derivative test, points of inflexion, Rolle's theorem, Lagrange's theorem, Cauchy's mean value theorem.

UNIT-IV

Higher order derivatives, calculation to the n^{th} derivative, determination of n^{th} derivative of rational functions. The n^{th} derivative of the products of power of sines and cosines, Leibnitz's theorem, the n^{th} derivative of the product of two functions, Maclaurin's theorem, Taylor's theorem.

TEXT BOOKS

1. Shanti Narayan and P. K. Mittal, Differential Calculus, S. Chand, 2015

RECOMMENDED BOOKS:

2. James Stewart, Calculus, 5th Edition, Brooks/Cole(Thomson), 2003.
3. Robert Wrede and Murray R. Spiegel, Advanced Calculus, 3rd Edition, Schaum's Outline Series (McGraw Hill), 2010.
4. Maurice D Weir, Frank R. Giordano and Joel Hass, Thomas' Calculus, 11th Edition, Pearson, 2008.
5. N. Piskunov, Differential and Integral Calculus, Mir Publishers, Moscow (CBS Publishers & Distributors, India), 1996.

UC-BSHM-102-19	Co-ordinate Geometry	L-4, T-1, P-0	4 Credits

Pre-requisite: A basic knowledge of two-dimensional Cartesian plane.

Course Objectives: This course is designed to introduce the geometry of two dimensions. The major focus of this course will be on geometric definition of two-dimensional shapes and a rigorous discussion on their properties and use.

Course Outcomes: At the end of the course, the students will be able to

CO1	Explain the different types of plane figures.
CO2	Visualize two-dimensional shapes geometrically.
CO3	Apply the knowledge of geometry of two dimensions in advance courses in mathematics.
CO4	Explain the Cartesian and Polar coordinate systems to study two dimensional shapes.
CO5	Study further the geometry of three dimensions.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	1	3	2	2	3
CO2	1	3	2	2	3
CO3	2	3	2	2	3
CO4	3	3	2	2	3
CO5	1	1	2	2	3

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Course Title: Co-ordinate Geometry
Course Code: UC-BSHM-102-19

UNIT-I

Joint equation of pair of straight lines and angle between them, condition of parallelism and perpendicularity, joint equation of the angle bisectors, joint equation of lines joining origin to the intersection of a line and a curve.

UNIT-II

General equation of circle, circle through intersection of two lines, tangent and normal, Chord of contact, pole and polar, pair of tangents from a point, equation of chord in midpoint form, angle of intersection and orthogonality, power of a point w.r.t. circle, radical axis, co-axial family of circles, limiting points.

UNIT-III

Parabola, ellipse and hyperbola, tangent and normal, chord of contact, pole and polar of tangent from a point, equation of chord in terms of midpoint, diameter, conjugate diameters of ellipse and hyperbola, conjugate hyperbola, asymptotes of hyperbola, rectangular hyperbola.

UNIT-IV

Transformation of axes in two dimensions: shifting of origin, rotation of axes, the second degree equation $S = ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$, its invariants t, Δ and O. Reduction of the second degree equation into standard form. Identification of curves represented by $S=0$ (including pair of lines).Polar equations of straight lines, circles and conics. Polar equation of chords, tangent and normal.

TEXT BOOKS

1. P. K. Jain, Khalid Ahmed, A Text book of Analytical Geometry of Two Dimensions, Wiley Eastern Ltd, 1999.

RECOMMENDED BOOKS:

2. S. L. Loney, The Elements of Coordinate Geometry, Macmillian & Comp., London, 2007

UC-BSHM-103-19	Programming Lab-I	L-0, T-0, P-2	2 Credits
Pre-requisite: Knowledge of basic concepts in Mathematics, such as, graphs, functions, conics, matrices etc.			
Course Objectives: This course is designed to introduce the basic knowledge of computer programming t simple algebraic operations on matrices and to visualize the geometry of curves and conics. two dimensions. The major focus of this course will be on geometric definition of two-dimensional shapes and a rigorous discussion on their properties and use.			
Course Outcomes: At the end of the course, the students will be able to			
CO1	Explain the basic concepts of programming.		
CO2	Apply the knowledge of programming in different Matrix Operations.		
CO3	Use programming in plotting and visualization of graphs of algebraic and transcendental functions.		
CO4	Obtain Surface of revolution of curves.		
CO5	Study further the tracing of conics.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	1	3	3	3	3
CO2	1	3	3	3	3
CO3	2	2	3	3	3
CO4	3	3	2	2	3
CO5	2	3	2	2	3

Course Title: Programming Lab-I

Course Code: UC-BSHM-103-19

The following programs with following methods are to be practiced to:

i) Introduce the programming through (FORTRAN, C etc.)

ii) Perform Matrix Operations, such as, Addition, Multiplication, inverse, Transpose etc.

iii) Plot the graphs of algebraic and transcendental functions (For example, e^{ax+b}, $\log(ax + b)$, $\frac{1}{ax+b,}$ with constants a, b, etc.)

iv) Obtain the surface of revolution of curves.

v) Trace of conics in Cartesian Coordinates /Polar Coordinates.

vi) Applications of derivative.

RECOMMENDED BOOKS:

1. V. Rajaraman, Computer Programming in Fortran 90 and 95, PHI Learning, 2004.
2. Ian Chivers and Jane Sleightholme, Introduction to Programming with Fortran, Springer, 4th edition, 2018.
3. Walter S. Brainerd, Guide to Fortran 2008 Programming, Springer Nature, 2015.

UC-BSHP-112-19	Electricity and Magnetism	L-3, T-1, P-0	4 Credits

Pre-requisite: Basic knowledge of Electricity and Magnetism at high school level.

Course Objectives: The objective of the course is to expose the students to the formal structure of electricity and magnetism so that they can use these as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and describe the different concepts of electromagnetism
CO2	To obtain the electric and magnetic fields for simple configurations under static conditions.
CO3	To analyse time varying electric and magnetic fields.
CO4	To understand Maxwell's equation in different forms and different media.
CO5	have a solid foundation in fundamentals required to solve problems and also to pursue higher studies.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	2	1	2	2	2	3	2	2
CO2	3	2	1	-	2	2	1	2	2	3	2	3
CO3	3	2	3	-	2	1	2	1	2	3	2	3
CO4	3	2	3	2	-	2	2	3	2	3	3	3
CO5	2	2	3	2	-	2	2	3	2	3	3	3

Course Title: Electricity and Magnetism

Course Code: UC-BSHP-112-19

UNIT-I

Review of Vector Analysis: Vector algebra, scalar and vector product; Concept of Fields; scalar and vector field; gradient, divergence and curl and their physical significance; Conservative field, Line, surface and volume integral of a vector field, Gauss-divergence theorem and Stoke's theorem.

UNIT II

Electrostatics: Electrostatic field; electric flux; Gauss's law in differential and integral form; Applications of Gauss law-Electric filed due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charge sheet; Electric potential as line integral of electric field, potential due to point charge and electric dipole; calculation of electric field from potential; Poisson's equation and Laplace's equation(Cartesian coordinate); Capacitance; capacitance of a spherical conductor and cylindrical capacitor, Energy per unit volume in electrostatic field, Dielectric medium, dielectric polarization and its types, Displacement vector, Boundary conditions.

UNIT-III

Magnetostatics: Magnetic flux; magnetic flux density; Faraday's law; magnetomotive force; Biot-Savart's law and its applications-straight conductor, circular coil, divergence and curl of magnetic field; Ampere's Circuital law in differential and integral form; Magnetic vector potential; ampere's force law; magnetic vector potential; Energy stored in a magnetic field, boundary conditions on magnetic fields.

UNIT-IV

Maxwell's Equations and Electromagnetic Waves: Equation of continuity for time varying fields; Inconsistency of ampere's law; concept of sinusoidal time variations (Phasor notation); Maxwell's equations in differential and integral form, physical significance; Maxwell equations in free space, static field and in Phasor notation; Difference between displacement current and conduction current; Wave equation in free space and in homogenous medium, Concept of Poynting vector; Poynting Theorem.

RECOMMENDED BOOKS:

1.David Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private Limited; 4th Edition.

2. E.C. Jordan and K.G. Balmain, Electromagnetic waves and radiating systems, Prentice Hall

3. Kraus John D, Electromagnetics, McGraw-Hill Publisher

4. W. Saslow, Electricity, magnetism and light, Academic Press

5.A Textbook of Electricity and Magnetism, S K Sharma, Shalini Sharma, S Dinesh & Co.

6. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.

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UC-BSHP-113-19	**Physics Lab-I**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisite (If any): High-school education			
Course Objectives: The aim and objective of the lab course is to introduce the students to the formal structure of electromagnetism and phenomenon of wave optics so that they can use these as per their requirement.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Able to verify the theoretical concepts/laws learnt in theory courses.		
CO2	Trained in carrying out precise measurements and handling sensitive equipment.		
CO3	Understand the methods used for estimating and dealing with experimental uncertainties and systematic "errors".		
CO4	Learn to draw conclusions from data and develop skills in experimental design.		
CO5	Document a technical report which communicates scientific information in a clear and concise manner.		

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	1	-	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	1	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

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Course Title: Physics Lab-I

Course Code: UC-BSHP-113-19

Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

List of experiments:

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the laser beam characteristics like; wave length, aperture, spot size, etc. using diffraction grating.
3. To study the diffraction using laser beam and thus to determine the grating element.
4. To study wavelength and laser interference using Michelson's Interferometer.
5. To find the refractive index of a material/glass using spectrometer.
6. To find the refractive index of a liquid using spectrometer.
7. To determine the resolving power of a prism.
8. To study the magnetic field of a circular coil carrying current using a Steward and Gees Tangent Galvanometer.
9. Determine the radius of circular coil using the Circular coil.
10. To study B-H curve using CRO.
11. To find out polarizability of a dielectric substance.
12. To find out the horizontal component of earth's magnetic field (B_h).

RECOMMENDED BOOKS:

1. A Text -book of Practical Physics, I. Prakash & Ramakrishna, 11thEdn, 2011, Kitab Mahal.
2. Engineering Practical Physics, S. Panigrahi& B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
4. Practical Physics, C L Arora. S. Chand & Company Ltd.
5. http://www.vlab.co.in

UGCA-1902	Fundamentals of Computer and IT	L-3, T-1, P-0	4 Credits
Pre-requisite: NA			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understanding the concept of input and output devices of Computers		
CO2	Learn the functional units and classify types of computers, how they process information and how individual computers interact with other computing systems and devices.		
CO3	Understand an operating system and its working, and solve common problems related to operating systems		
CO4	Learn basic word processing, Spreadsheet and Presentation Graphics Software skills.		
CO5	Study to use the Internet safely, legally, and responsibly		

Course Title: Fundamentals of Computer and IT
Course Code: UGCA-1902

UNIT-I

Human Computer Interface: Concepts of Hardware and Software; Data and Information.
Functional Units of Computer System: CPU, registers, system bus, main memory unit, cache memory, Inside a computer, SMPS, Motherboard, Ports and Interfaces, expansion cards, ribbon cables, memory chips, processors.

Devices: Input and output devices (with connections and practical demo), keyboard, mouse, joystick, scanner, OCR, OMR, bar code reader, web camera, monitor, printer, plotter.

Data Representation: Bit, Byte, Binary, Decimal, Hexadecimal, and Octal Systems, Conversions and Binary Arithmetic (Addition/ Subtraction/ Multiplication) Applications of IT.

UNIT II

Concept of Computing, Types of Languages: Machine, assembly and High level Language; Operating system as user interface, utility programs.
Word processing: Editing features, formatting features, saving, printing, table handling, page settings, spell-checking, macros, mail-merge, equation editors.

UNIT-III

Spreadsheet: Workbook, worksheets, data types, operators, cell formats, freeze panes, editing features, formatting features, creating formulas, using formulas, cell references, replication, sorting, filtering, functions, Charts & Graphs.
Presentation Graphics Software: Templates, views, formatting slide, slides with graphs, animation, using special features, presenting slide shows.

UNIT-IV

Electronic Payment System: Secure Electronic Transaction, Types of Payment System: Digital Cash, Electronic Cheque, Smart Card, Credit/Debit Card E-Money, Bit Coins and Crypto currency, Electronic Fund Transfer (EFT),Unified Payment Interface(UPI), Immediate Payment System(IMPS), Digital Signature and Certification Authority. Introduction to Bluetooth, Cloud Computing, Big Data, Data Mining, Mobile Computing and Embedded Systems and Internet of Things (IoT).

RECOMMENDED BOOKS:

1. Introduction to Information Technology, ITL Education Solutions limited, Pearson Education

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2. Computer Fundamentals, A. Goel, 2010, PearsonEducation.
3. Fundamentals of Computers, P. K.Sinha& P. Sinha, 2007, BPBPublishers.
4. IT Tools, R.K. Jain, Khanna PublishingHouse
5. “IntroductiontoInformationTechnology”,SatishJain,AmbrishRai&Shashi Singh, Paperback Edition, BPB Publications,2014.
6. “Introduction to Computers”, Peter Norton
7. Computers Today, D. H. Sanders, McGraw Hill.
8. “Computers”, Larry long & Nancy long, Twelfth edition, PrenticeHall.
9. ProblemSolvingCasesinMicrosoftExcel,JosephBrady&EllenFMonk,Thomson Learning
10. www.sakshat.ac.in
11. https://swayam.gov.in/course/4067-computer-fundamentals

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UGCA-1906	Fundamentals of Computer and IT Laboratory	L-0, T-0, P-4	2 Credits
Pre-requisite (If any):NA			
CO1	Familiarizing with Open Office (Word processing, Spreadsheets and Presentation).		
CO2	To acquire knowledge on editor, spread sheet and presentation software.		
CO3	The students will be able to perform documentation and accounting operations.		
CO4	Students can learn how to perform presentation skills.		

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Course Title: Fundamentals of Computer and IT Laboratory

Course Code: UGCA-1906

List of experiments:

- **Word Orientation:** The instructor needs to give an overview of word processor. Details of the four tasks and features that would be covered Using word – Accessing, overview of toolbars, saving files, Using help and resources, rulers, format painter.

  1) Using word to create Resume:
     Features to be covered:- Formatting Fonts in word, Drop Cap in word, Applying Text effects,Using Character Spacing, Borders and Colors, Inserting Header and Footer, Using Date and Time option in Word.
  2) Creating an Assignment
     Features to be covered:- Formatting Styles, inserting table, Bullets and Numbering, Changing Text Direction, Cell alignment, Footnote, Hyperlink, Symbols, Spell Check, Track Changes.
  3) Creating a Newsletter
     Features to be covered :- Table of Content, Newspaper columns, Images from files and clipart, Drawing toolbar and Word Art, Formatting Images, Textboxes and Paragraphs
  4) Creating a Feedback form
     Features to be covered :- Forms, Text Fields, Inserting objects, Mail Merge in Word.

- **Excel Orientation:** The instructor needs to tell the importance of Excel as a Spreadsheet tool, give the details of the four tasks and features that would be covered Excel - Accessing, overview of toolbars, saving excel files.

  1) Creating a Scheduler
     Features to be covered :- Gridlines, Format Cells, Summation, auto fill, Formatting Text
  2) Creating an Assignment
     Features to be covered:- Formatting Styles, inserting table, Bullets and Numbering, Changing Text Direction, Cell alignment, Footnote, Hyperlink, Symbols, Spell Check, Track Changes.
  3) Creating a Newsletter
     Features to be covered :- Table of Content, Newspaper columns, Images from files and clipart, Drawing toolbar and Word Art, Formatting Images, Textboxes and Paragraphs
  4) Creating a Feedback form
     Features to be covered :- Forms, Text Fields, Inserting objects, Mail Merge in Word.

➢ **Presentation Orientation:**

1) Students will be working on basic power point utilities and tools which help them create basic power point presentation.
Topic covered includes :- PPT Orientation, Slide Layouts, Inserting Text, Word Art, Formatting Text, Bullets and Numbering, Auto Shapes, Lines and Arrows
2) This session helps students in making their presentations interactive.
Topicscoveredincludes:Hyperlinks,Inserting–Images,ClipArt,Audio,Video, Objects, Tables and Charts
3) Concentrating on the in and out of Microsoft power point. Helps them learn best practices in designing and preparing power point presentation. Topics covered includes: - Master Layouts (slide, template, and notes), Types of views (basic, presentation, slide slotter, notes etc), Inserting – Background, textures,DesignTemplates,Hiddenslides.Autocontentwizard,SlideTransition, Custom
4) Animation, Auto Rehearsing
5) Power point test would be conducted. Students will be given model power point presentation which needs to be replicated

➢ **Internet and its Applications:** The instructor needs to tell the how to configure Web Browser and to use search engines by defining search criteria using Search Engines

1) To learn to setup an e-mail account and send and receive e-mails.
2) Tolearntosubscribe/postonablogandtousetorrentsforaccelerateddownloads.
3) Hands on experience in online banking and Making an online payment for any domestic bill.

RECOMMENDED BOOKS:

1. IT Tools, R.K. Jain, Khanna Publishing House.
2. Introduction to Information Technology, ITL Education Solutions limited, Pearson Education.
3. Introduction to information technology, Turban, Rainer and Potter, John Wiley and Sons.
4. ProblemSolvingCasesinMicrosoftExcel,JosephBrady&EllenFMonk,Thomson Learning.

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Course Title: Inorganic Chemistry
Course Code: UC-BSHC-101-19

UNIT-I

Atomic Structure: Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: deBroglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and $\psi 2$. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

UNIT-II

Chemical Bonding-I: Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations, Packing of ions in crystals, Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy, Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids, Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

UNIT-III

Chemical Bonding-II: Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach), Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl,BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valenceshell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths, Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ioniccharacter from dipole moment and electronegativity difference.

UNIT-IV

Chemistry of s and p Block Elements: Inert pair effect, Relative stability of different oxidation states, diagonal relationship andanomalous behaviour of first member of each group, Allotropy and catenation, Complex formation tendency of s and p block elements, Hydrides and their classification ionic, covalent and interstitial, Basic beryllium acetate and

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nitrate. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses, Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine, Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

RECOMMENDED BOOKS:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
6. Shriver & Atkins, Inorganic Chemistry 5th Ed.

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Course Title: Chemistry Lab-I

Course Code: UC-BSHC-102-19

List of Experiments:

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized KMnO4 solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilicacid) and external indicator.

Reference text:

1. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS.

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BBA-GE101-18	Managerial Economics I	L-5, T-1, P-0	6 Credits
Pre-requisite: Understanding of basic knowledge of Managerial Economics			
Course Objectives: The primary objective of this course is to equip students with the necessary economic concepts, principles, theory and techniques and enhance their managerial decision making to address business problems in a globalized economic environment.			
Course Outcomes: After completion of the course, the students shall be able to:			

CO1	Understand the basic concepts of managerial economics and apply the economic way of thinking to individual decisions and business decisions.
CO2	Measure price elasticity of demand, understand the determinants of elasticity and apply the concepts of price, cross and income elasticity of demand.
CO3	Understand and estimate production function and Law of Diminishing Marginal Utility.
CO4	Understand and explain four basic market models of perfect competition, monopoly, monopolistic competition, and oligopoly, and how price and quantity are determined in each model.
CO5	Understand the different costs of production and how they affect short and long run decisions.

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Course Title: Managerial Economics I

Course Code: BBA-GE101-18

UNIT-I

Introduction to Managerial Economics: Managerial Economics: Meaning, Nature, Scope & Relationship with other disciplines, Role of managerial economics in decision Making, Opportunity Cost Principle, Production Possibility Curve, Incremental Concept, Scarcity Concept.

Demand and the Firm: Demand and its Determination: Demand function; Determinants of demand; Demand elasticity – Price, Income and cross elasticity. Use of elasticity for analyzing demand, Demand estimation, Demand forecasting, Demand forecasting of new product. **Indifference Curve Analysis:** Meaning, Assumptions, Properties, Consumer Equilibrium, Importance of Indifference Analysis, Limitations of Indifference Theory

UNIT-II

Production Function : Production function Meaning, Concept of productivity and technology, Short Run and long run production function Isoquants; Least cost combination of inputs, Producer's equilibrium; Return to scale; Estimation of production function.

Theory of Cost: Cost Concepts and Determinants of cost, short run and long run cost theory, **Modern** Theory of Cost, Relationship between cost and production function

UNIT-III

Revenue Curve: Concept of Revenue, Different Types of Revenues, concept and shapes of Total Revenue, Average revenue and marginal revenue, Relationship between Total Revenue, Average revenue and marginal revenue, Elasticity of Demand and Revenue relation

Market Structure: Market Structure: Meaning, Assumptions and Equilibrium of Perfect Competition, Monopoly, Monopolistic Competition, Oligopoly: Price and output determination under collusive oligopoly, Price and output determination under non-collusive oligopoly, Price leadership model.

UNIT-IV

Pricing: Pricing practices; Commodity Pricing: Economics of advertisement costs; Types of pricing practices

Factor Pricing: Demand and supply of factor of production; Collective bargaining, Concept of rent, profit, interest- Rate of return and interest rates; Real vs. Nominal interest rates. Basic capital theory–Interest rate and return on capital. Measurement of profit.

Note: Relevant Case Studies will be discussed in class.

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RECOMMENDED BOOKS:

1. K.K .Dewett, *Modern Economic Theory,* S. Chand Publication
2. D.M.Mithani, *Managerial Economics Theory and Applications,* Himalaya Publication
3. Peterson and Lewis, *Managerial Economic,* Prentice Hall of India
4. Gupta, *Managerial Economics,* TataMcGraw Hills
5. Geetika, *Managerial Economics,* Tata McGraw Hills
6. D.N.Dwivedi, *Managerial Economic,* Vikas Publications
7. Froeb, *Managerial Economics*, Cengage Learning
8. Koutsoyiannis, A, Modern Micro Economics, Palgrave Macmillan Publishers, New Delhi.
9. Thomas Christopher R., and Maurice S. Charles, Managerial Economics – Concepts and Applications, 8th Edition,
10. Mehta, P. L, Managerial Economics – Analysis, Problems and Cases, Sultan Chand & Sons, Delhi.
11. Peterson and Lewis, Managerial Economics, 4th Edition, Prentice Hall of India Pvt. Ltd., New Delhi.
12. Shapiro, Macro Economics, Galgotia Publications.

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UC-BSHL-105-19	Communicative English -I	L-2, T-0, P-0	2 Credits
Pre-requisite: Basic proficiency in Communication Skills			

Course Objectives: The main objective of this course is:

- To help the students become proficient in LSRW-Listening, Speaking, Reading & Writing skills
- To help the students become the independent users of English language
- To develop in them vital communication skills, integral to their personal, social and professional interactions
- To teach them the appropriate language of professional communication
- To prepare them for job market

Course Outcomes: At the end of the course, the student will

CO1	acquire basic proficiency in reading &listening, writing and speaking skills
CO2	be able to understand spoken and written English language, particularly the language of their chosen technical field.
CO3	be able to converse fluently.
CO4	be able to produce on their own clear and coherent texts.
CO1	become proficient in professional communication, such as, interviews, group discussions, office environments, important reading skills as well as writing skills and thereby will have better job prospects.

Mapping of course outcomes with the program Specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	1	1	2	2	3	2	3	2	2
CO2	1	-	-	1	1	2	2	3	2	3	2	2
CO3	1	-	-	1	1	2	2	3	2	3	2	2
CO4	1	-	-	1	1	2	2	3	2	3	2	2
CO5	2	-	-	1	1	2	2	3	2	3	2	2

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Course Title: Communicative English -I
Course Code: UC-BSHL-105-19

UNIT I(Literature)

(A) The Poetic Palette (Orient Black Swan, Second Edition, 2016)

The following poems from this anthology are prescribed:

1. Pippa's Song: Robert Browning
2. Apparently With No Surprise: Emily Dickinson
3. Fool and Flea: Jeet Thayil

(B) Prose Parables (Orient Black Swan, 2013)

The following stories from the above volume are prescribed:

a. The Kabuliwallah : Rabindranath Tagore
b. The Eyes Are Not Here: Ruskin Bond
c. Grief: Anton Chekov

UNIT-II

Vocabulary: Word Formation Processes; Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives; Synonyms, antonyms

Grammar: Subject-verb agreement; Noun-pronoun agreement; Misplaced modifiers; Articles

Determiners; Modals; Prepositions;

UNIT-III

Reading and Understanding: Close Reading; Comprehension;

UNIT-IV

Mechanics of Writing & Speaking Skills

Essay Writing (Descriptive/Narrative/Argumentative); Business letters; Précis Writing; Self Introductions; Group Discussion

RECOMMENDED BOOKS:

1. John Eastwood, Oxford Practice Grammar, Oxford University Press, 2014
2. Michael Swan, Practical English Usage, OUP. 1995.
3. F.T. Wood, Remedial English Grammar, Macmillan. 2007.
4. William Zinsser, On Writing Well, Harper Resource Book 2001.
5. Sanjay Kumar and Pushp Lata, Oxford University Press. 2011.
6. Communication Skills, Oxford University Press. 2011.
7. Liz Hamp-Lyons and Ben Heasly, Study Writing, Cambridge University Press. 2006.

UC-BSHL-106A-19	ਪੰਜਾਬੀਲਾਜ਼ਮੀ (Punjabi Compulsory)-I	L-2, T-0, P-0	2 Credits
Pre-requisite: Understanding of senior secondary level Punjabi			

Course Objectives: The objective of the course is:
1.To enhance the language ability of students.

2.To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.

Course Outcomes: At the end of the course, the student will be able to

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

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Course Title: ਪੰਜਾਬੀਲਾਜ਼ਮੀ (Punjabi Compulsory)-I
Course Code: UC-BSHL-106A-19

UNIT-I

ਕਵਿਤਾਭਾਗ:

ਭਾਈਵੀਰਸਿੰਘ:

ਸਮਾਂ, ਚਸ਼ਮਾ

ਪ੍ਰੋ.ਪੂਰਨਸਿੰਘ :

ਪੰਜਾਬਨੂੰਕੂਕਾਂਮੈਂ, ਹੱਲਵਾਹੁਣਵਾਲੇ

ਪ੍ਰੋ.ਮੋਹਨਸਿੰਘ :

ਮਾਂ,ਕੋਈਆਇਆਸਾਡੇਵਿਹੜੇ,ਪਿਆਰਪੰਧ

ਅੰਮ੍ਰਿਤਾਪ੍ਰੀਤਮ:

ਆਖਾਂਵਾਰਿਸਸ਼ਾਹਨੂੰ,ਅੰਨਦਾਤਾ

UNIT-II

ਕਹਾਣੀਭਾਗ:ਸੰਤਸਿੰਘਸੇਖੋਂ :

ਪੇਮੀਦੇਨਿਆਣੇ

ਸੁਜਾਨਸਿੰਘ :

ਕੁਲਫੀ

ਕੁਲਵੰਤਸਿੰਘਵਿਰਕ :

ਤੂੜੀਦੀਪੰਡ

ਗੁਰਦਿਆਲਸਿੰਘ :

ਸਾਂਝ

UNIT-III

ਭਾਸ਼ਾਦਾਟਕਸਾਲੀਰੂਪ, ਭਾਸ਼ਾਤੇਉਪ-ਭਾਸ਼ਾਵਿਚਅੰਤਰ, ਪੰਜਾਬੀਦੀਆਂਉਪ-ਭਾਸ਼ਾਵਾਂ,ਪੰਜਾਬੀਭਾਸ਼ਾ:ਨਿਕਾਸਤੇਵਿਕਾਸ।

ਭਾਸ਼ਾਤੇਲਿਪੀ, ਗੁਰਮੁਖੀਲਿਪੀਦੀਆਂਵਿਸ਼ੇਸ਼ਤਾਵਾਂ, ਗੁਰਮੁਖੀਲਿਪੀ: ਨਿਕਾਸਤੇਵਿਕਾਸ।

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UNIT-IV

ਸੰਖੇਪਰਚਨਾ (ਪ੍ਰੈਸੀ)

ਪੈਰ੍ਹਾਰਚਨਾ

ਸਰਲਅੰਗਰੇਜ਼ੀਪੈਰ੍ਹੇਦਾਪੰਜਾਬੀਅਨੁਵਾਦ

RECOMMENDED BOOKS:

1.ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ,2016.

UC-BSHL-106B-19	**ਮੁਢਲੀ ਪੰਜਾਬੀ (Mudhli Punjabi)-I**	**L-2, T-0, P-0**	**2 Credits**
Pre-requisite: Understanding of senior secondary level Punjabi			
Course Objectives: The objective of the course is to: 1.enhance the language ability of students. 2.enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture.
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

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Course Title: (Mudhli Punjabi)-I
Course Code: UC-BSHL-106B-19

UNIT-I

ਪੈਂਤੀ ਅੱਖਰੀ (ਵਰਣਮਾਲਾ), ਅੱਖਰ ਕ੍ਰਮ
ਮਾਤਰਾਵਾਂ : ਮੁਢਲੀ ਜਾਣ-ਪਛਾਣ
ਲਗਾਖਰ :ਬਿੰਦੀ, ਟਿੱਪੀ, ਅੱਧਕ

UNIT-II

ਪੰਜਾਬੀ ਸ਼ਬਦ ਬਣਤਰ: ਮੁਢਲੀ ਜਾਣ-ਪਛਾਣ
ਮੂਲ ਸ਼ਬਦ , ਅਗੇਤਰ, ਪਿਛੇਤਰ
ਸਮਾਨਾਰਥਕ ਸ਼ਬਦ, ਵਿਰੋਧਾਰਥਕ ਸ਼ਬਦ
ਸ਼ੁੱਧ- ਅਸ਼ੁੱਧ: ਦਿੱਤੇ ਪੈਰ੍ਹੇ ਵਿੱਚੋਂ ਅਸ਼ੁੱਧ ਸ਼ਬਦ ਨੂੰ ਸ਼ੁੱਧ ਕਰਨਾ

UNIT-III

ਹਫਤੇ ਦੇ ਸੱਤ ਦਿਨਾਂ ਦੇ ਨਾਂ
ਬਾਰ੍ਹਾਂ ਮਹੀਨਿਆਂ ਦੇ ਨਾਂ
ਰੁੱਤਾਂ ਦੇ ਨਾਂ
ਇਕ ਸੌ ਤੱਕ ਗਿਣਤੀ ਸ਼ਬਦਾਂ ਵਿਚ

UNIT-IV

ਸਧਾਰਣ ਸ਼ਬਦਾਂ ਦਾ ਅੰਗਰੇਜ਼ੀ ਤੋਂ ਪੰਜਾਬੀ ਅਨੁਵਾਦ

ਸਧਾਰਣ ਸ਼ਬਦਾਂ ਦਾ ਪੰਜਾਬੀ ਤੋਂ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ

ਸੰਖੇਪਰਚਨਾ (ਪ੍ਰੈਸੀ)

ਪੈਰ੍ਹਾਰਚਨਾ

ਸਰਲਅੰਗਰੇਜ਼ੀਪੈਰ੍ਹੇਦਾਪੰਜਾਬੀਅਨੁਵਾਦ

Text and Reference Books

1.ਸੁਖਵਿੰਦਰ ਸਿੰਘ ਸੰਘਾ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਵਿਗਿਆਨ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਅਕਾਦਮੀ ਜਲੰਧਰ

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SEMESTER-II

UC-BSHM-201-19	Calculus-II	L-4, T-1, P-0	4 Credits
Pre-requisite: Calculus-I			
Course Objectives: The objectives of this course are to make the students understand the following: 1. The applications of differential calculus for tracing curves. 2. The concept of Integration and its definition as limit of sum and area under curve. 3. The relation between derivative and the integration of a function. 4. The concept of improper integrals. 5. Numerical techniques to find approximate integrals and applications of integration for length of arc, finding area and volume.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Understand the techniques to sketch a curve using the concepts of differential calculus.
CO2	Visualize all concepts of differential calculus geometrically
CO3	Understand the concept of Integration.
CO4	Understand the fundamental relation between differential and Integral Calculus.
CO5	Apply the knowledge of integral calculus in finding length of arc, area under curves, volume and area of surface swept by curve during revolution.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3

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Course Title: Calculus-II
Course Code: UC-BSHM-201-19

UNIT-I

Concavity and Convexity, points of inflexion, derivative of arc, radius of curvature, centre of curvature, chord of curvature, evolutes and involutes.

UNIT-II

Asymptotes, working rules of determining Asymptotes, Asymptotes in polar co-ordinates, Cusps, curve tracing (Cartesian and polar), introduction to envelopes.

UNIT-III

Anti derivative of function of real variable, Riemann sums, definite integrals and their properties, Indefinite integral and net change, the fundamental theorem of calculus, Improper Integrals: Infinite Integrals, Discontinuous intervals, comparison test for improper integrals (Scope: James Stewart; Chapter-), reduction formulae.

UNIT-IV

Approximate Integration: Midpoint rule, Trapezoidal rule, Simpson's rule; applications of integrals to find length of arc and area between curves, finding volumes, area of surface of revolution.

TEXT BOOKS

1.James Stewart, Calculus, 5th Edition, Brooks/Cole(Thomson), 2003.
2.Maurice D Weir, Frank R. Giordano and Joel Hass, Thomas' Calculus, 11th Edition, Pearson, 2008.
3.Shanti Narayan and P. K. Mittal: Differential Calculus, S. Chand

REFERENCE BOOKS

4.George B. Thomas and Ross. L. Finney: Calculus and Analytic Geometry, 9th Edition, Addison Wesley, 1998.

UC-BSHM-202-19	Solid Geometry	L-4, T-1, P-0	4 Credits
Pre-requisite: Two dimensional coordinate geometry.			
Course Objectives: This course is designed to introduce the geometry of three dimensions. The major focus of this course will be on geometric interpretation of three-dimensional shapes and a rigorous discussion on their properties and use.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Use the idea of three-dimensional Cartesian coordinate system, shift of origin and rotation of axes.
CO2	Demonstrate knowledge and understanding of three dimensional shapes and their properties.
CO3	Visualize the three dimensional shapes, for example sphere, cylinder and cone etc.
CO4	Utilize the knowledge of geometry of three dimensions in other branches of mathematics, for example calculus and analysis.

Mapping of course outcomes with the program Specific outcomes.

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	3
CO2	3	3	3	2	3
CO3	1	2	3	2	3
CO4	1	3	3	3	3

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Course Title: Solid Geometry
Course Code: UC-BSHM-202-19

UNIT-I

Lines and planes in 3-dimension, change of axes, shift of origin, rotation of axes, sphere, and section of a sphere by a plane. Sphere through a given circle. Intersection of a line and sphere.

UNIT-II

Tangent and normal, tangent plane, angle of intersection of two spheres and condition of orthogonality, power of a point w.r.t. a sphere, Radical planes, radical axis, radical centre, coaxial family of spheres, limiting points.

UNIT-III

Cylinder, Cone, homogeneous equation of second degree in x, y, z, reciprocal cone, right circular and elliptic cones, surface of revolution, enveloping cones, right circular and elliptic cylinders. Hyperbolic cylinder.

UNIT-IV

Quadratic surfaces: Ellipsoid, hyperboloid, paraboloid, quadratic cone, tangent plane and normal.

REFERENCE BOOKS

1.P. K. Jain, Khalid Ahmad, Textbook of Analytical Geometry, 3rd Edition, New Age International Publishers, 2018.

2.Shanti Narayan, P.K. Mittal, Analytical Solid Geometry, 17th Revised Edition, S. Chand & Company, 2007.

UC-BSHM-203-19	Computer Algebra System: MATLAB	L-0, T-0, P-2	2 Credits
Pre-requisite: Knowledge of basic concepts in Mathematics such as graphs, functions, conics, matrices etc.			
Course Objectives: This course is designed to introduce a Computer Algebra System: MATLAB which is currently used in scientific computations. The main focus will be on introduction to basic concepts of MATLAB using simple examples.			
Course Outcomes: At the end of the course, the students will be able to			
CO1	Explain the basic concepts of programming		
CO2	Visualize functions in 2-D and 3-D		
CO3	Make their own computer programs for solving problems of their interest		
CO4	Use symbolic tools of MATLAB for solving problems arising in various fields of applications		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	3	3	3	3
CO2	1	3	3	3	3
CO3	2	2	3	3	3
CO4	3	3	2	2	3

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Course Title: Computer Algebra System: MATLAB

Course Code: UC-BSHM-203-19

UNIT-I

The MATLAB environment, scalars, variables, arrays, mathematical operations with arrays, built-in and user defined functions, graphics: two-dimensional and three-dimensional, m-files: script and function files, functions: input; disp and fprintf, relational and logical operators.

UNIT-II

Symbolic math: symbolic objects and expressions; collect; expand; factor; simplify; solve; diff and int commands, Programming: if-end structure; if-else-end structure; loops: for-end and while-end.

Reference Books.

1.D. J. Highamand N. J. Higham, MATLAB Guide, 2nd Edition, Society for Industrial and Applied Mathematics (SIAM), 2005.

2.Amos Gilat, MATLAB: An Introduction with Applications, 5th Edition, John Wiley & Sons, 2014.

UC-BSHP-124-19	Waves and Vibrations	L-4, T-0, P-0	4 Credits
Pre-requisite: Understanding of senior secondary level Physics and Mathematics			
Course Objectives: The objective of the course is to develop basic understanding of Interference, Diffraction and Polarization among students. The Students also learn about the LASER and its applications. Students will be equipped with knowledge to measure wavelength, refractive index and other related parameters, which will act as a strong background if he/she chooses to pursue sciences as a career.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Identify and illustrate physical concepts and terminology used in optics and other related wave phenomena
CO2	Analyze and understand the phenomenon of interference, and diffraction and their applications
CO3	Get thorough knowledge of the polarization of light and its changes upon reflection and transmission and will learn to analyze the polarization in optical systems.
CO4	Understand the simple harmonic motion and its application.
CO5	Describe the different types of lasers, its principle, properties of laser beam.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	-	1	2	1	2	3	2	2
CO2	2	2	1	2	1	1	1	1	1	3	1	1
CO3	3	2	2	2	1	1	2	1	1	3	1	1
CO4	2	2	2	2	1	1	2	1	1	3	1	1
CO5	2	2	2	2	1	1	2	1	1	3	1	1

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Course Title: Waves and Vibrations
Course Code: UC-BSHP-124-19

UNIT I

Interference: Electromagnetic nature of light, Definition and properties of wave front, Huygens Principle, Temporal and Spatial Coherence, Division of amplitude and wave front, Young's double slit experiment, Lloyd's single mirror and Fresnel's Biprism, Interference in Thin Films, Newton's Rings and Michelson Interferometer. (11 Lectures)

UNIT-II

Diffraction and Polarization: Huygens Principle, Huygens-Fresnel Diffraction theory, Fraunhofer diffraction: Single slit. Circular aperture, Rayleigh criterion of resolution, Resolving Power of a telescope, Double slit, Multiple slits, Diffraction grating; Polarization, Plane polarized light, Representation of Unpolarized and Polarized light, Polarization by Reflection, Brewster's law, Malus Law, Polarization by Selective absorption by Crystals, Polarization by Scattering, Polarization by Double Refraction.
(11 Lectures)

UNIT-III

Simple Harmonic Motion: Simple harmonic motion, Energy of a SHO, Simple, Compound and Torsional pendulum, Electrical Oscillations, damped oscillations, damped harmonic oscillator – heavy, critical, and light damping, Damping coefficients, energy decay in a damped harmonic oscillator, quality factor, forced mechanical oscillators, resonance. (12 Lectures)

UNIT-IV

Laser and Application: Lasers, Spontaneous emission, Stimulated absorption, Stimulated emission, Einstein coefficients, Conditions for Laser actions, Population inversion, Different types of Laser, Pumping mechanism: Optical Pumping, Electric Discharge and Electrical pumping, Resonators, Two, Three, and Four level laser systems, Ruby laser, He-Ne gas Laser, Semiconductor laser, CO2 laser, applications of laser: Holography, Principle of Holography.
(11 Lectures)

Text and Reference Books:

1. Optics: A.K. Ghatak (Tata-McGraw Hill), 1992.
2. Fundamentals of Optics: F.A. Jenkins and H.E. White (McGraw Hill), 1981.
3. A Text Book of Optics: Subrahmaniyam N. &et al.(S. Chand Publishing) (2006).
4. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010.

UC-BSHP-125-19	Physics Lab-II	L-0, T-0, P-4	2 Credits

Pre-requisites (if any): High-school education with Physics lab as one of the subject.

Course Objectives: The aim and objective of the Physics Lab course is to introduce the students of B. Sc. (Hons.) Physics to the formal structure of wave and vibrations and mechanics so that they can use these as per their requirement.

Course Outcomes: At the end of the course, the student will be

CO1	Able to understand the theoretical concepts learned in the theory course.
CO2	Trained in carrying out precise measurements and handling equipment.
CO3	Learn to draw conclusions from data and develop skills in experimental design.
CO4	Able to understand the principles of error analysis and develop skills in experimental design.
CO5	Able to document a technical report which communicates scientific information in a clear and concise manner.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	1	-	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	1	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

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Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

List of experiments:

1. Measurement of volume using travelling microscope. Use of Plumb line and Spirit level.
2. To determine the frequency of an electrically maintained tuning fork in a) Transverse mode of vibration b) Longitudinal mode of vibration.
3. To find out the frequency of AC mains using sonometer.
4. To study the characteristic of Ge-Si junction diode.
5. To analyze the suitability of a given Zener diode as a power regulator.
6. To determine the horizontal and vertical distance between two points using a Sextant.
7. To determine the height of an inaccessible object using a Sextant.
8. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of **g** and (c) Modulus of rigidity.
9. To determine the time period of a simple pendulum for different length and acceleration due to gravity.
10. To study the variation of time period with distance between centre of suspension and centre of gravity for a compound pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.
11. To find the moment of inertia of an irregular body about an axis through its C.G with the torsional pendulum.
12. To determine the angular acceleration α, torque τ, and Moment of Inertia of flywheel.

Reference book and suggested readings:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11thEdn, 2011, Kitab Mahal.
4. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
6. Practical Physics, C L Arora, S. Chand & Company Ltd.

http://www.vlab.co.in

UGCA-1909	**Object Oriented Programming using C++**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: NA			
Course Outcomes: At the end of the course, the student will be able to			
CO1	To learn programming from real world examples.		
CO2	To understand Object oriented approach for finding Solutions to various problems with the help of C++ language.		
CO3	To create computer based solutions to various real-world problems using C++		
CO4	To learn various concepts of object oriented approach towards problem solving		

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Course Title: Object Oriented Programming using C++
Course Code: UGCA-1909

UNIT-I

Principles of object oriented programming
Introduction to OOP and its basic features, Basic components of a C++, Program and program structure, Compiling and Executing C++ Program. Difference between Procedure Oriented Language(C) and Object Oriented Language. (12)

UNIT-II

Classes & Objects and Concept of Constructors
Defining classes, Defining member functions, Declaration of objects to class, Access to member variables from objects, Different forms of member functions, Access specifiers (Private, public, protected), Array of objects. Introduction to constructors, Parameterized constructors, Copy Constructor, Multiple constructors in class, Dynamic initialization of objects, Destructors. (10)

UNIT-III

Inheritance and Operator overloading
Introduction to Inheritance, Types of inheritance: - Single inheritance, Multiple inheritance, Multilevel inheritance, Hierarchical inheritance, Hybrid inheritance, Defining operator overloading, Overloading of Unary and Binary operators, Rules for overloading operators. (10)

UNIT-IV

Polymorphism and File Handling
Early Binding, Late Binding, Virtual Functions, pure virtual functions, Abstract Classes. Opening and Closing File, Reading and Writing a file. (10)

Text Books:

1. Object Oriented Programming with C++, E. Balagurusami, Fourth Edition, Tata Mc-Graw Hill.
2. Object Oriented Programming in Turbo C++, Robert Lafore, Fourth Edition Galgotia Publications.
3. The C++ Programming Language, Bjarna Stroustrup, Third Edition, Addison-Wesley Publishing Company.
4. Object Oriented Programming Using C++, Salaria, R. S, Fourth Edition, Khanna Book Publishing.

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UGCA-1910	Object Oriented Programming using C++	L-0, T-0, P-4	2 Credits
Pre-requisite (If any):NA			
CO1	To learn programming from real world examples.		
CO2	To understand Object oriented approach for finding Solutions to various problems with the help of C++ language.		
CO3	To create computer based solutions to various real-world problems using C++		
CO4	To learn various concepts of object oriented approach towards problem solving		

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Course Title: Object Oriented Programming using C++ Laboratory

Course Code: UGCA-1910

Instructions: Develop all program in C++

Assignments:

1. Write a program to enter mark of 6 different subjects and find out the total mark.(Using cin and cout statement)

2. Write a function using reference variables as arguments to swap the values of pair of integers.

3. Write a function to find largest of three numbers.

4. Write a program to find the factorial of a number.

5. Define a class to represent a bank account which includes the following members as Data members: a) Name of the depositor b) Account Number c) Withdrawal amount d) Balance amount in the account

Member Functions:

a) To assign initial values b)To deposit an amount c) To withdraw an amount after checking the balance d) To display name and balance.

6. Write the above program for handling n number of account holders using array of objects.

7. Write a C++ program to compute area of right angle triangle, equilateral triangle, isosceles triangle using function overloading concept.

8. Consider a publishing company that markets both book and audio cassette version to its works. Create a class Publication that stores the title (a string) and price (type float) of a publication. Derive the following two classes from the above Publication class: Book which adds a page count (int) and Tape which adds a playing time in minutes(float). Each class should have get_data() function to get its data from the user at the keyboard. Write the main() function to test the Book and Tape classes by creating instances of them asking the user to fill in data with get_data() and thenndisplaying it using put_data().

9. Consider an example of declaring the examination result. Design three classes student, exam and result. The student has data members such as rollno, name. Create the lass exam by inheriting the student class. The exam class adds data members representing the marks scored in 5 subjects. Derive the result from exam-class and it has own data members like total, avg.

10. Write a program for overloading of Unary ++ operator.

11. Write a program for overloading of Binary + operator.

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12. Write a program of Virtual Functions.
13. Write a program of Abstract Classes.
14. Write a program to read and write from file.

Reference Books:

1. Object Oriented Programming with C++, E. Balagurusami, Fourth Edition, Tata Mc-Graw Hill.
2. Object Oriented Programming in Turbo C++, Robert Lafore, Fourth Edition Galgotia Publications.
3. The C++ Programming Language, Bjarna Stroustrup, Third Edition, Addison- Wesley Publishing Company.
4. Object Oriented Programming Using C++, Salaria, R. S, Fourth Edition, Khanna Book Publishing.

UC-BHCL-113-19	Introduction to Organic Chemistry	L-3, T-1, P-0	4 Credits

Pre-requisite: Knowledge of basic concepts in Mathematics, such as graphs, functions, conics, matrices etc.

Course Objectives:

1. To teach the basic principles, reaction mechanisms and stereochemistry of organic compounds.
2. To impart knowledge regarding physical properties and chemical reactions of alkanes, alkenes, dienes, alkynes, arenes, alkyl and aryl halides etc.
3. To predict and account for the most commonly encountered reaction mechanisms (substitution, addition and elimination) in organic chemistry.
4. To teach the basic principles, reaction mechanisms and stereochemistry of organic compounds.
5. To impart knowledge regarding physical properties and chemical reactions of alkanes, alkenes, dienes, alkynes, arenes, alkyl and aryl halides etc.
6. To predict and account for the most commonly encountered reaction mechanisms (substitution, addition and elimination) in organic chemistry

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the fundamental concepts of organic chemistry i.e structure, bonding and various effects in organic compounds.
CO2	To learn the stereochemistry viz. optical isomerism, stereoisomerism and conformational isomerism of organic compounds.
CO3	To study the various known reactive intermediate in organic synthesis
CO4	To learn the fundamental and advanced concepts of reaction mechanisms along with the study of reaction mechanisms in various types of substitution addition and elimination reactions.
CO5	To predict the relationships between organic chemical structures and their reactivity.

Mapping of course outcomes with the program outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	-	2	-	3	1	-
CO2	2	-	3	-	3	3	-
CO3	3	3	4	-	3	3	-
CO4	3	4	3	4	4	5	4
CO5	2	3	4	2	4	4	4

Course Title: Introduction to Organic Chemistry

Course Code: UC-BHCL-113-19

Unit-I

Basics of Organic Chemistry Organic Compounds:

Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyper conjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. (11)

Unit-II

Introduction to types of organic reactions: -

Introduction to the types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. Stereochemistry: Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

(12)

Unit-III

Chemistry of Aliphatic Hydrocarbons

A. **Carbon-Carbon sigma bonds Chemistry of alkanes**: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. **Carbon-Carbon π- bonds:** Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction.

(12)

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Unit-IV

Aromatic Hydrocarbons Aromaticity:

Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

(10)

REFERENCE BOOKS:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)

3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994

5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

UC-BHCP-119-19	Introduction to Organic Chemistry Lab	L-0, T-0, P-4	2 Credits

Pre-requisite: Knowledge of basic concepts in Mathematics, such as, graphs, functions, conics, matrices etc.

Course Objectives:

The objective of this course is to provide practical knowledge and illustrative experiments regarding qualitative analysis, isolation, and purification of organic compounds

Course Outcomes: At the end of the course, the students will be able to

CO1	To check the purity of organic compounds by determining the melting or boiling points.
CO2	To develop preparative skills for purification of organic compounds by crystallization method.
CO3	To determine the element or functional groups present in organic compound by organic qualitative analysis.
CO4	To present their work with practical skills and the awareness of health and safety procedures.
CO5	To apply related experiments for their research work.

Mapping of course outcomes with the program Specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	-	2	-	3	1	-
CO2	2	-	3	-	3	3	-
CO3	3	3	4	-	3	3	-
CO4	3	4	3	4	4	5	4
CO5	2	3	4	2	4	4	4

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Course Title: Introduction to Organic Chemistry Lab
Course Code: UC-BHCP-119-19

Unit-I

Determination of melting point

Napthalene 80-82°, Benzoic acid 121.5-122°, Urea 132.5-133°, Succinic acid 184.5-185°, Cinnamic acid 132.5-133°, Salicylic acid 157.5-158°, Acetanilide 113.5-114°, m-Dinitrobenzene 90°, p-Dichlorobenzene 52°, Aspirin 135°

Determination of boiling point

Ethanol 78°, Cyclohexane 81.4°, Toluene 110.6°, Benzene 80°

Unit-II

Distillation

Simple distillation of ethanol-water mixture using water condenser
Distillation of nitrobenzene and aniline using air condenser

Crystallization

Concept of induction of crystallization
Phthalic acid from hot water (using fluted filter paper and stemless funnel)
Acetanilide from boiling water
Napthalene from ethanol
Benzoic acid from water

Unit-III

Qualitative Analysis

Elemental analysis

nitrogen, sulphur, chlorine, bromine, iodine

Functional groups

-phenols, carboxylic acids

Unit-IV

-carbonyl compounds - ketones, aldehydes
-carbohydrates
-aromatic amines
-amides, ureas and anilides
-aromatic hydrocarbons and their halo- derivatives

Reference Books

1.Brian S. Furniss, Antony J. Hannaford, Peter W.G. Smith and Austin R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Longman, London.

2. F.G. Mann and B. C. Saunders, Practical Organic Chemistry, Springer

3. J.T. Sharp, Practical Organic Chemistry: A student handbook of techniques.

4. Philippa B. Cranwell, Laurence M. Harwood and Cristopher J. Moody , Experimental Organic Chemistry, 3rd Edition, Wiley.

BBA-GE 201-18	Managerial Economics II	L-5, T-1, P-0	6 Credits

Pre-requisite: Understanding of basic knowledge of Managerial Economics

Course Objectives: This course aims to acquaint students with economy as a whole including measurement of national income, inflation and unemployment, which an objective to inculcate understanding of macroeconomic environment of an economy for better decision making.

Course Outcomes: After completion of the course, the students shall be able to:

CO1	Explain the concept of national income and its measurement using different approaches.
CO2	Describe the underlying theories of demand and supply of money in an economy.
CO3	Make use of employment and national income statistics students will be able to describe and analyze the economy in quantitative terms.
CO4	Interpret macroeconomic issues like money, inflation and unemployment.
CO5	Identify the phases of the business cycle and the problems caused by cyclical fluctuations in the market economy

Mapping of course outcomes with the program o Specific utcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	2	3	2	2	-
CO2	3	2	2	3	2	3	
CO3	2	3	3	2	2	3	3
CO4	2	2	3	3	3	2	3
CO5	2	1	1	3	1	1	3

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Course Title: Managerial Economics II

Course Code: BBAGE 201-18

UNIT-I

National Income: Measuring National Income. Problems in the measurement of National Income. Theories of Money: Nature and functions of money – Types of money: Near money, inside money and outside money. Theories of demand for money – defining demand for money – Classical theories of demand for money – Friedman's re-statement of Quantity Theory of Money; Liquidity preference theory and Keynesian Liquidity Trap. Theories of Supply of money; Defining supply of money; Measuring supply of money.

UNIT-II

Theories of Inflation and Unemployment: Meaning, Types and Theories of Inflation. - Cost of inflation and sacrifice ratio. - Measurement of Inflation in India - Policies to control inflation Meaning and types of unemployment. - Cost of unemployment and Oakun's Law Measurement of unemployment in India. - Concept of Stagflation - Concept of Philips Curve.

Unit-III

Business cycle: Meaning, types and phases. Monetary, Fiscal and Income policy – Meaning and instruments. Multiplier: Concept, Features and Leakages. Foreign trade multiplier.

Unit-IV

Macro-economic Framework in Indian Economy–Public Finance–Tax system in India– Financial Administration: Finance Commission.

RECOMMENDED BOOKS:

1. Ahuja, H.L.(2015) Macroeconomics-Theory and Policy. New Delhi: Sultan Chand.

2. Jhingan, M.L. (2016) Macro Economic Theory. Delhi: Vrinda Publications Pvt. Ltd

3. Dwivedi, D.N.(2017)Macroeconomics: Theory and Practice: Theory & Practice. New Delhi: McGraw Hill.

4. Jain, T.R., Khanna, O.P.(2014) Managerial Economics: V.K. Publications

5. Dewett, K.K., Navalur, M.H., (2006) Modern Economic Theory: New Delhi: Sultan Chand.

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UC-BHHL-115-19	Communicative English -II	L-2, T-0, P-0	2 Credits

Pre-requisite: Basic proficiency in Communication Skills

Course Objectives: The main objective of this course is:

- To help the students become proficient in LSRW-Listening, Speaking, Reading & Writing skills
- To help the students become the independent users of English language
- To develop in them vital communication skills, integral to their personal, social and professional interactions
- To teach them the appropriate language of professional communication
- To prepare them for job market

Course Outcomes: At the end of the course, the student will

CO1	acquire basic proficiency in reading &listening, writing and speaking skills
CO2	be able to understand spoken and written English language, particularly the language of their chosen technical field.
CO3	be able to converse fluently.
CO4	be able to produce on their own clear and coherent texts.
CO5	become proficient in professional communication, such as, interviews, group discussions, office environments, important reading skills as well as writing skills and thereby will have better job prospects.

Mapping of course outcomes with the program Specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	2	3	2	2	2
CO2	3	2	2	3	2	3	3
CO3	2	3	3	2	2	3	3
CO4	2	2	3	3	3	2	3
CO5	2	1	1	3	1	1	3

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Course Title: Communicative English-II
Course Code: BHHL115-19

UNIT-I
(Literature)

(C) ***The Poetic Palette* (Orient BlackSwan, Second Edition, 2016)**

The following poems from this anthology are prescribed:

4. The Soul's Prayer: Sarojini Naidu
5. I Sit and Look Out: Walt Whitman
6. Women's Rights: Annie Louise Walker

(D) ***Prose Parables* (Orient Black Swan, 2013)**

The following stories from the above volume are prescribed:

a. The Doctor's Word: R.K. Narayan
b. The Doll's House: Katherine Mansfield
c. Dusk: H.H. Munroe (Saki) (10)

UNIT-II

Vocabulary:

Standard abbreviations; One word substitution; Word Pairs (Homophones/Homonyms)

Grammar: Sentence Structures; Use of phrases and clauses in sentences; Transformation of Sentences; Importance of proper punctuation (6)

UNIT-III

Reading and Understanding:

Summary Paraphrasing; Analysis and Interpretation; Translation (from Hindi/Punjabi to English and vice-versa)

Close Reading; Comprehension;

(4)

UNIT-IV

Mechanics of Writing & Speaking Skills:

Report writing; Career Documents- Job applications, Resume/CV writing, Common Everyday Situations: Conversations & Dialogues, Formal Presentations

(10)

REFERENCE BOOKS

1.John Eastwood, Oxford Practice Grammar, Oxford University Press,2014
2.Michael Swan, Practical English Usage, OUP. 1995.
3. **F.T.Wood,** Remedial English Grammar,Macmillan,2007.
4. William Zinsser, On Writing, Well Harper Resource Book, 2001.
5. Sanjay Kumar and Pushp Lata, Communication Skills, Oxford University Press,2011.'
6.Liz Hamp-Lyons and Ben Heasly, Study Writing, Cambridge University Press. 2006.

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UC-BHHL-116A	PUNJABI COMPULSORY-II (ਪੰਜਾਬੀ ਲਾਜ਼ਮੀ-II)	L:2 , T:0, P:0	Credits:2
Pre-requisite:	**ਪੰਜਾਬੀਲਾਜ਼ਮੀ (Punjabi Compulsory)-I**		
Course Objectives	1. To enhance the language ability of students. 2. To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.		

Course Outcomes: At the end of the course, the student will be able to

CO1. Translate and transfer/broadcast the western scientific knowledge in the local language.

CO2. Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.

CO3. Understand the society through Punjabi language, literature and culture.

CO4. Learning science and in developing science literacy.

CO5. Improve the internal communication.

Mapping of course outcomes with the program Specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	3
CO5	2	3	2	2	2

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Course Title: PUNJABI COMPULSORY-II (ਪੰਜਾਬੀ ਲਾਜ਼ਮੀ-II)
Course Code: BHHL116A-19

UNIT-I

ਡਾ.ਹਰਿਭਜਨ ਸਿੰਘ:
ਅਪ੍ਰਮਾਣਿਕ, ਤੇਰੇ ਹਜ਼ੂਰ ਮੇਰੀ ਹਾਜ਼ਰੀ ਦੀ ਦਾਸਤਾਨ
ਸ਼ਿਵ ਕੁਮਾਰ ਬਟਾਲਵੀ:
ਕੰਡਿਆਲੀ ਥੋਹ੍ਰ, ਧਰਮੀ ਬਾਬਲ ਪਾਪ ਕਮਾਇਆ, ਰੁੱਖ
ਪਾਸ਼:
ਇਨਕਾਰ,ਸਭ ਤੋਂ ਖਤਰਨਾਕ,ਦਹਿਕਦੇ ਅੰਗਿਆਰਾਂ 'ਤੇ
ਸੁਰਜੀਤ ਪਾਤਰ:
ਹੁਣ ਘਰਾਂ ਨੂੰ ਪਰਤਣਾ, ਕੁਝ ਕਿਹਾ ਤਾਂ..., ਪੁਲ

(8)

UNIT-II

ਕਹਾਣੀ ਭਾਗ:
ਸੰਤੋਖ ਸਿੰਘ ਧੀਰ:
ਕੋਈ ਇਕ ਸਵਾਰ
ਪ੍ਰੇਮ ਪ੍ਰਕਾਸ਼:
ਲੱਛਮੀ
ਮੋਹਨ ਭੰਡਾਰੀ :
ਘੋਟਣਾ
ਵਰਿਆਮ ਸਿੰਘ ਸੰਧੂ :
ਆਪਣਾ ਆਪਣਾ ਹਿੱਸਾ

(8)

UNIT-III

ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਦੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ
ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਉਪਰ ਪਏ ਪ੍ਰਭਾਵ

(6)

UNIT-IV

ਰਿਪੋਰਟਿੰਗ, ਸਮਾਚਾਰ ਲਿਖਣ ਦੀ ਵਿਧੀ ਤੇ ਤੱਤ
ਪੰਜਾਬੀ ਪੈਰ੍ਹੇ ਦਾ ਸਰਲ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ
ਦਫਤਰੀ ਚਿੱਠੀ ਪੱਤਰ

(8)

Reference Books

ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ, 2016.

UC-BHHL-116B	MUDHLI PUNJABI-II (ਮੁਢਲੀ ਪੰਜਾਬੀ-II)	L:2 , T:0, P:0	Credits:2
Pre-requisite:	ਮੁਢਲੀ ਪੰਜਾਬੀ (Mudhli Punjabi)-I		
Course Objectives	1. To enhance the language ability of students. 2. To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.		

Course Outcomes: At the end of the course, the student will be able to

- **CO1.** Translate and transfer/broadcast the western scientific knowledge in the local language.
- **CO2.** Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
- **CO3.** Understand the society through Punjabi language, literature and culture.
- **CO4.** Learning science and in developing science literacy.
- **CO5.** Improve the internal communication.

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	3
CO5	2	3	2	2	2

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Course Title: MUDHLI PUNJABI-II (ਮੁਢਲੀ ਪੰਜਾਬੀ-II)
Course Code: BHHL116B-19

UNIT-I

ਸ਼ਬਦ ਸ਼੍ਰੇਣੀਆਂ : ਪਛਾਣ ਤੇ ਵਰਤੋਂ-
ਨਾਂਵ, ਪੜਨਾਂਵ
ਵਿਸ਼ੇਸ਼ਣ, ਕਿਰਿਆ
ਕਿਰਿਆ ਵਿਸ਼ੇਸ਼ਣ

(8)

UNIT-II

ਰੋਜ਼ਾਨਾ ਵਰਤੋਂ ਦੀ ਪੰਜਾਬੀ ਸ਼ਬਦਾਵਲੀ:
ਬਾਜ਼ਾਰ, ਵਪਾਰ, ਰਿਸ਼ਤੇ-ਨਾਤੇ ਤੇ ਕਿੱਤਿਆਂ ਸਬੰਧੀ।

(8)

UNIT-III

ਪੰਜਾਬੀ ਵਾਕ ਬਣਤਰ :
ਸਧਾਰਣ ਵਾਕ
ਸੰਯੁਕਤ ਵਾਕ
ਮਿਸ਼ਰਤ ਵਾਕ

(8)

UNIT-IV

ਸਧਾਰਣ ਵਾਕਾਂ ਦਾ ਅੰਗਰੇਜ਼ੀ ਤੋਂ ਪੰਜਾਬੀ ਅਨੁਵਾਦ

ਸਧਾਰਣ ਵਾਕਾਂ ਦਾ ਪੰਜਾਬੀ ਤੋਂ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ

(8)

Reference Books

1.ਸੁਖਵਿੰਦਰ ਸਿੰਘ ਸੰਘਾ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਵਿਗਿਆਨ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਅਕਾਦਮੀ ਜਲੰਧਰ

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SEMESTER-III

UC-BSHM-301-19	Calculus-III	L-4, T-1, P-0	4 Credits
Pre-requisite: - Calculus of one variable			
Course Objectives: The objectives of the course are to introduce the functions of several variable, the continuity, derivatives and integrals of the functions of several variables and their geometrical interpretations. One of the objectives is to introduce the applicability of the calculus of several variables to the students.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Understand the functions of several variables and their behavior.
CO2	Find the partial derivatives, understand its geometrical meaning and understand their relation with total derivative
CO3	Find the maxima and minima of function of several variables and their expansion.
CO4	Understand the integrals of the functions of several variables and their geometrical interpretation
CO5	Applications of the calculus of several variables in the real world.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	-	-	3
CO2	3	3	-	-	3
CO3	3	3	-	-	3
CO4	3	3	-	-	3
CO5	1	3	-	-	3

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Course Title: Calculus-III

Course Code: UC-BSHM-301-19

UNIT-I

Real valued functions of several variables with emphasis on functions of two and three variables, Limits and continuity, Partial derivatives, Homogenous Functions, Euler's Theorem

UNIT-II

Total differentiation, Differentiation of composite functions, Implicit functions, Chain Rule, Jacobians, Directional Derivatives, Gradient Vectors, Tangent Planes.

UNIT-III

Saddle Points, Maxima and Minima of functions of two variables, Lagrange's multiplier method, Higher dimensional analogues of Lagrange's Mean value Theorem and Taylor's theorem for functions of two variables.

UNIT-IV

Double integration over rectangular and non-rectangular regions, change of order of integration, double integration in polar co-ordinates, triple integration over parallelepiped and other solid regions, Applications of double and triple integrals to area, volume, centre of gravity, moment of inertia etc.

RECOMMENDED BOOKS:

1. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 9th Edition, Addison Wesley, 1998. (Scope as in Ch.11-13)
2. Shanti Narayan and P.K. Mittal, Differential Calculus, S. Chand & Co.
3. Shanti Narayan and P.K. Mittal, Integral Calculus, S. Chand & Co.
4. T. M. Apostol, Mathematical Analysis, 2nd Edition, Narosa Publishing House, Reprint 2002.
5. J. Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

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UC-BSHM-302-19	Algebra-I	L-4, T-1, P-0	4 Credits

Pre-requisite: - Complex numbers, Sets, Relation and Functions

Course Objectives: This course is designed to introduce the basic notions of algebra. The major focus of the course will be on: De Moivre's theorem & its applications, matrices and their use in system of equations; theoretical foundation of theory of equations and their solutions.

Course Outcomes: At the end of the course, the students will be able to

CO1	Use the De Moivre's theorem for solving problems concerning powers of complex numbers and complex roots of polynomials etc.
CO2	Use matrices in solving system of equations.
CO3	Demonstrate linear independence and dependence of a set of vectors.
CO4	Find inverse of a matrix using Gauss-Jordan method.
CO5	Demonstrate the nature of solutions of polynomial equations.
CO6	Use Cardano's method, Ferrari method and Descarte's method for finding solutions of equations.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	3	-	-	1
CO2	2	3	-	-	1
CO3	3	3	-	-	1
CO4	2	3	-	-	1
CO5	3	3	-	-	1
CO6	3	3	-	-	1

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Course Title: Algebra-I
Course Code: UC-BSHM-302-19

UNIT-I

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications. Linear independence and dependence of row and column vectors, elementary operations on matrices, inverse of a matrix using Gauss-Jordan method, echelon form, row rank and column rank of a matrix and their equivalence,

UNIT-II

System of linear equations (homogeneous and non-homogeneous), conditions for consistency, Polynomials, zeros of a polynomial, division algorithm, greatest common divisor, repeated roots, equal roots, fundamental theorem of algebra.

UNIT-III

Relationship between roots and the coefficients, Fundamental theorem of symmetric polynomials (without proof). Evaluation of symmetric functions of roots, Rational roots of polynomials with integral coefficients. Descartes' rule of sign.

UNIT-IV

Strum's theorem (statement only), Solution of cubic equation using Cardano's method, and biquadratic equation by Descartes method and Ferrari's method.

RECOMMENDED BOOKS

1. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Springer Nature, 2016

2.Shanti Narayan and P.K. Mittal, A Textbook of Matrices, S. Chand & Company, 2010.

3.S. Lipschutz and M. L. Lipson, Schaum's Outline of Linear Algebra, McGraw Hill Education, 3rd Edition, 2017.

4.A Kurosh, Higher Algebra, Moscow Mir Publisher, 1972.

5.H. W. Turnbull, Theory of Equations, Palala Press, 2018.

6.W. S. Burnside and A. W. Panton, The Theory of Equations, Vol-1, Dublin University Press, 1954.

7. Chandrika Prasad, Text Book on Algebra and Theory of Equations, Pothishala Pvt. Ltd., 2017.

UC-BSHM-303-19	Real Analysis-I	L-4, T-1, P-0	4 Credits

Pre-requisite: Students must have the knowledge of number system, limit.

Course Objectives: The objective of the course on **Real Analysis-I** is to equip the B.Sc. (Hons) students with the real line, its properties. The various concepts of sequence, infinite series. Furthermore, students will be introduced to various tests to discuss the convergence, divergence of sequences and infinite series.

Course Outcomes: At the end of the course, the student will be able to

CO1	Learn the basic concepts of Real line and its properties.
CO2	Understand about bounded, unbounded and limit suprema and infima.
CO3	Use of Monotone Convergence theorem for the calculation of square roots.
CO4	Be acquainted with knowledge of convergent and divergent sequences.
CO5	Apply the learnt tests in establishing convergence, divergence, absolute convergence and conditional convergence of infinite series.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	1
CO5	2	2	2	2	1

Course Title: Real Analysis-I
Course Code: UC-BSHM-303-19

UNIT-I

Review of Algebraic properties, Rational and irrational numbers, Order properties of $\mathbb{R}$, Absolute value of a real number, Triangle inequality, Real line, δ-neighborhood of a point in $\mathbb{R}$, Idea of bounded above sets, bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of $\mathbb{R}$ (without proof).

UNIT-II

Sequence of real number, Limit of a sequence, Uniqueness of limits, Limit theorems, Bounded sequence, Convergent sequence, Squeeze theorem, Examples of divergent sequences, Monotone sequence, Monotone convergence theorem, Calculation of square roots, Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano-Weierstrass Theorem for Sequences, Cauchy sequence, Cauchy's Convergence Criterion.

UNIT-III

Infinite series, convergence and divergence of infinite series, The n^{th} term test, Harmonic series, Geometric series, Cauchy Criterion for convergence, Integral test, p-test, Comparison test, Limit Comparison test, Ratio test, Cauchy root test.

UNIT-IV

Absolute Convergence of infinite series, Comparison test, Root test, Ratio Test, Cauchy integral test, Kummer's test, Raabe's Test, Non-absolute convergence of infinite series, Alternating series, Leibniz test, Abel's Lemma, Abel's test, Dirichlet test.

RECOMMENDED BOOKS

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Edition. Singapore: John Wiley and Sons (Asia) Pvt. Ltd., 2002.
2. R.T. Smith, and R.B. Minton, R.B. Calculus, 4th Edition. McGraw-Hill Education, 2011.
3. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer International Publishing, 2018.
4. T.M. Apostol, Calculus, Volume I &II, 2nd edition. New Delhi: Wiley, 1969.
5. R.K. Jain and S.K. Iyengar, S.K. Advanced Engineering Mathematics, 5th Edition. New Delhi: Narosa Publication, 2011.
6. W.R. Wade, An Introduction to Analysis, 4th Edition. Person, 2010.

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UC-BSHP-214-19	Elements of Modern Physics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: The objective of the course is to develop basic understanding concepts of modern physics, namely to special relativity and to the quantum nature of light and energy, emphasizing whenever possible, how classical concepts have shown up to be inadequate in explaining experiments, which will act as a strong background if he/she chooses to pursue science as a career.

Course Outcomes: At the end of the course, the student will be able to

CO1	gained a deep understanding on the motivations that have led in the past century to the relativistic and quantum revolution in physics
CO2	demonstrate ability to apply wave-particle duality and uncertainty principle to solve physics problems.
CO3	demonstrate ability to solve quantum mechanical eigenvalue equations for various operators and obtain expectation values of the corresponding observables.
CO4	demonstrate ability to solve 1-D quantum problems including the quantum particle in a box, a well, the simple harmonic oscillator, and the transmission and reflection of waves.
CO5	solve problems involving the quantization of mass, charge, light, and energy including Avogadro's number, black-body radiation, photoelectric effect, and other related issues.

Mapping of course outcomes with the program Specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	-	1	2	1	2	3	2	2
CO2	2	2	1	2	1	1	1	2	1	3	2	1
CO3	3	2	2	2	1	1	2	2	1	3	2	1
CO4	2	2	2	2	1	1	2	1	1	3	1	2
CO5	2	2	2	2	1	1	2	1	1	3	1	1

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Course Title: Elements of Modern Physics
Course Code: UC-BSHP-214-19

UNIT-I

Dual Nature of Waves and Matter: Black body ration, Planck's quantum, Planck's constant and light as a collection of photons; Photo Electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment, Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

Lecture (10)

UNIT-II

Quantum Mechanics: Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; wave velocity and group velocity, Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wave function, probabilities and normalization; Probability and probability current densities in one dimension. One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example.

Lecture (10)

UNIT-III

Atomic structure: The nuclear atom, Electron orbits, Atomic spectra, The Bohr Model, Energy level and spectra, Correspondence principle, Nuclear motion, Atomic excitation, Many electron atoms, Exclusion Principle, electron spin, spin orbit coupling, X-ray spectra. Zeeman effect, Stern-Garlach experiment.

Lecture (10)

UNIT-IV

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Doppler effect, Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. Energy- Momentum Four Vector.

Lecture (10)

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Recommended Books:

1. Arthur Beiser, , Concepts of Modern Physics, 2009, McGraw-Hill
2. J.R. Taylor, C.D. Zafirato and M.A. Dubson, Modern Physics, 2009, PHI Learning
3. Thomas A. Moore, Six Ideas that Shaped Physics: Particle Behave like Waves, 2003, McGraw Hill
4. E.H. Wichman, Quantum Physics, Berkeley Physics, Vol.4., 2008, Tata McGraw-Hill Co.
5. R.A. Serway, C.J. Moses, and C.A.Moyer, Modern Physics, 2005, Cengage Learning.

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UC-BSHP-215-19	Physics Lab-III	L-0, T-0, P-4	2 Credits

Pre-requisites (if any): High-school education with Physics lab as one of the subject.

Course Objectives: The aim and objective of the Physics Lab course is to introduce the students of B. Sc. (Hons.) Physics to the formal structure of wave and vibrations and mechanics so that they can use these as per their requirement.

Course Outcomes: At the end of the course, the student will be

CO1	Able to understand the theoretical concepts learned in the theory course.
CO2	Trained in carrying out precise measurements and handling equipment.
CO3	Learn to draw conclusions from data and develop skills in experimental design.
CO4	Able to understand the principles of error analysis and develop skills in experimental design.
CO5	Able to document a technical report which communicates scientific information in a clear and concise manner.

Mapping of course outcomes with the program Specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	3	3	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	2	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

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Course Title: Physics Lab-III
Course Code: UC-BSHP-215-19

Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To show the tunneling effect in tunnel diode using I-V characteristics.
3. To determine work function of material of filament of directly heated vacuum diode
4. To determine value of Planck's constant using LEDs of at least 4 different colors.
5. Measurement of Planck's constant using black body radiation and photo-detector.
6. To determine work function of material of filament of directly heated vacuum diode.
7. To determine the ionization potential of mercury.
8. To determine the wavelength of H-alpha emission line of Hydrogen atom.
9. To determine the absorption lines in the rotational spectrum of Iodine vapour.
10. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.
11. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
12. To determine the value of e/m by magnetic focusing.
13. To experimentally demonstrate the concept of quantization of energy levels according to Bohr's model of atom using Franck-Hertz Apparatus.
14. To determine the wavelength of laser source using diffraction of single slit.
15. To determine the wavelength of laser source using diffraction of double slits.
16. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.

RECOMMENDED BOOKS:

1. http://vlab.amrita.edu/?sub=1&brch=195
2. Experimental Physics - M.A. Hippargi.
3. Experimental Physics – Gadad & Hiregoudar.
4. Practical Physics - C. L. Arora.
5. Advanced Practical Physics – Worsnop and Flint.
6. Practical Physics – Gupta & Kumar Vol I, Vol II

UGCA1914	**Programming in Python**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisites (if any): NA			
Course Outcomes: At the end of the course, the student will be			
CO1	Familiar with Python environment, data types, operators used in Python.		
CO2	Compare and contrast Python with other programming languages.		
CO3	Learn the use of control structures and numerous native data types with their methods.		
CO4	Design user defined functions, modules, and packages and exception handling methods.		
CO5	Create and handle files in Python and learn Object Oriented Programming Concepts.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	1	2	3	3	3
CO2	1	1	3	3	3
CO3	1	2	3	3	3
CO4	1	2	3	3	3
CO5	1	1	3	3	3

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Course Title: Programming in Python

Course Code: UGCA-1914

UNIT-I

Introduction to Python Programming Language: Programming Language, History and Origin of Python Language, Features of Python, Limitations, Major Applications of Python, Getting, Installing Python, Setting up Path and Environment Variables, Running Python, First Python Program, Python Interactive Help Feature, Python differences from other languages.

Python Data Types & Input/Output: Keywords, Identifiers, Python Statement, Indentation, Documentation, Variables, Multiple Assignment, Understanding Data Type, Data Type Conversion, Python Input and Output Functions, Import command.

Operators and Expressions: Operators in Python, Expressions, Precedence, Associativity of Operators, Non Associative Operators. (12)

UNIT-II

Control Structures: Decision making statements, Python loops, Python control statements.

Python Native Data Types: Numbers, Lists, Tuples, Sets, Dictionary, Functions & Methods of Dictionary, Strings (in detail with their methods and operations). (10)

UNIT-III

Python Functions: Functions, Advantages of Functions, Built-in Functions, User defined functions, Anonymous functions, Pass by value Vs. Pass by Reference, Recursion, Scope and Lifetime of Variables.

Python Modules: Module definition, Need of modules, Creating a module, Importing module, Path Searching of a Module, Module Reloading, Standard Modules, Python Packages. (12)

UNIT-IV

Exception Handling: Exceptions, Built-in exceptions, Exception handling, User defined exceptions in Python.

File Management in Python: Operations on files (opening, modes, attributes, encoding, closing), read() & write() methods, tell() & seek() methods, renaming & deleting files in Python, directories in Python. (10)

Classes and Objects: The concept of OOPS in Python, Designing classes, Creating objects, Accessing attributes, Editing class attributes, Built-in class attributes, Garbage collection, Destroying objects.

Text Books:

1. Pooja Sharma, Programming in Python, BPB Publications, 2017.
2. R. Nageswara Rao, Core Python Programming, 2nd Edition, Dreamtech.

Reference Books:

1. Martin C. Brown ,Python, The complete Reference , Mc Graw Hill Education.
2. A. Martelli, A. Ravenscroft and S. Holden, Python in a Nutshell, OREILLY.

UGCA1917	Programming in Python Laboratory	L-0, T-0, P-4	2 Credits

Pre-requisites (if any): NA

Additional material required in ESE: - Maintain practical note book as per the instructions given by the instructor.

CO1	Solve simple to advanced problems using Python language.
CO2	Develop logic of various programming problems using numerous data types and control structures of Python.
CO3	Implement different data structures.
CO4	Implement modules and functions.
CO5	Design and implement the concept of object oriented programming structures.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	1	2	3	3	2
CO2	1	1	3	3	2
CO3	1	2	3	3	2
CO4	1	2	3	3	2
CO5	1	1	2	3	2

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Course Title: Programming in Python Laboratory

Course Code: UGCA-1917

List of assignments:

1.	Compute sum, subtraction, multiplication, division and exponent of given variables input by the user.
2.	Compute area of following shapes: circle, rectangle, triangle, square, trapezoid and parallelogram.
3.	Compute volume of following 3D shapes: cube, cylinder, cone and sphere.
4.	Compute and print roots of quadratic equation $ax^2+bx+c=0$, where the values of a, b, and c are input by the user.
5.	Print numbers up to N which are not divisible by 3, 6, 9,, e.g., 1, 2, 4, 5, 7,….
6.	Write a program to determine whether a triangle is isosceles or not?
7.	Print multiplication table of a number input by the user.
8.	Compute sum of natural numbers from one to n number.
9.	Print Fibonacci series up to n numbers e.g. 0 1 1 2 3 5 8 13…..n
10.	Compute factorial of a given number.
11.	Count occurrence of a digit 5 in a given integer number input by the user.
12.	Print Geometric and Harmonic means of a series input by the user.
13.	Evaluate the following expressions: a. $x-x^2/2!+x^3/3!- x^4/4!+\ldots x^n/n!$ b. $x-x^3/3!+x^5/5!- x^7/7!+\ldots x^n/n!$
14.	Print all possible combinations of 4, 5, and 6.
15.	Determine prime numbers within a specific range.
16.	Count number of persons of age above 60 and below 90.
17.	Compute transpose of a matrix.
18.	Perform following operations on two matrices. 1) Addition 2) Subtraction 3) Multiplication
19.	Count occurrence of vowels.
20.	Count total number of vowels in a word.
21.	Determine whether a string is palindrome or not.
22.	Perform following operations on a list of numbers: 1) Insert an element 2) delete an element 3) sort the list 4) delete entire list
23.	Display word after Sorting in alphabetical order.
24.	Perform sequential search on a list of given numbers.
25.	Perform sequential search on ordered list of given numbers.
26.	Maintain practical note book as per their serial numbers in library using Python dictionary.
27.	Perform following operations on dictionary

	1) Insert 2) delete 3) change
28.	Check whether a number is in a given range using functions.
29.	Write a Python function that accepts a string and calculates number of upper case letters and lower case letters available in that string.
30.	To find the Max of three numbers using functions.
31.	Multiply all the numbers in a list using functions.
32.	Solve the Fibonacci sequence using recursion.
33.	Get the factorial of a non-negative integer using recursion.
34.	Write a program to create a module of factorial in Python.
35.	Design a Python class named *Rectangle,* constructed by a length & width, also design a method which will compute the area of a rectangle.
36.	Design a Python class named *Circle* constructed by a radius and two methods which will compute the area and the perimeter of a circle.
37.	Design a Python class to reverse a string 'word by word'.
38.	Write a Python program to read an entire *text file*.
39.	Design a Python program to read first n lines of a *text file.*
40.	Construct a Python program to write and append text to a file and display the text.

Text Books:

1.Pooja Sharma, Programming in Python, BPB Publications, 2017.

2.R. Nageswara Rao, Core Python Programming, 2nd Edition, Dreamtech.

Reference Books:

3. Martin C. Brown ,Python, The complete Reference , Mc Graw Hill Education.

4. A. Martelli, A. Ravenscroft, S. Holden, Python in a Nutshell, OREILLY.

UC-BHCL-204-19	PHYSICAL CHEMISTRY	L-3, T-1, P-0	4 Credits
Pre-requisite: Understanding of senior secondary level Physics and Mathematics			
Course Objectives: This course will equip students with the necessary knowledge concerning the fundamentals in the basic areas of physical chemistry viz. different states of matter, solutions and ionic equilibrium. The problem solving skills of students are expected to be enhanced through due weightage given to numerical problems in each unit.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Understand the basic principles and theories pertaining to different states of matter
CO2	Solve various problems related to pH
CO3	Define the various laws pertaining to gaseous state and solutions.
CO4	Familiarise with the different colligative properties of solutions and the concept of abnormal molecular mass
CO5	Understand the basic structure and symmetry elements in solids

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	-	3	-	-	3
CO2	-	3	-	-	3
CO3	-	3	-	-	3
CO4	-	3	-	-	3
CO5	-	3	-	-	3

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Course Tittle: Physical Chemistry
Course Code: UC-BHCP-204-19

UNIT-I

Gaseous State:
The kinetic molecular theory of gases, Postulates and derivation of kinetic gas equation and various gas laws, The ideal gas law: Applications, Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z and its variation with pressure for different gases. Causes of deviation from ideal behavior. van der Waals equation of state, its derivation and application in explaining real gas behaviour. Numericals.

UNIT-II

Liquid and Solid State
Physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity and their determination, cleansing action of detergents.

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law

UNIT-III

Ionic equilibria:
Concept of Acids and Bases. Electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids.
Buffer solutions; buffer capacity, buffer range, buffer action
Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

UNIT-IV

Solutions and Colligative Properties:
Ways of expressing the concentration, lowering of vapour pressure, Raoult's Law. Colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

RECOMMENDED BOOKS:

1. P.W. Atkins and J. de Paula, Atkin's Physical Chemistry, Oxford University Press (2006).
2. S.H. Maron and C.F. Prutton, Principles of Physical Chemistry, 1st edition,Oxford and IBH (1958).
3. G.W. Castellan, Physical Chemistry, 4th edition, Narosa (2004)
4. I .N. Levine, Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010)
5. T. Engel and P. Reid, Physical Chemistry 3rd Ed., Prentice-Hall (2012)

UC-BHCL-208-19	Chemistry Lab-III	L-0, T-0, P-4	2 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: To provide students practical knowledge and skills about various topics taught in theory class of physical chemistry, which in turn will enhance their problem solving and analytical skills.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the basic procedures for carrying out a physical chemistry practical like preparation and standardisation of solutions, handling the equipments and measuring with precision.
CO2	Correlate the theoretical and practical aspects and know about the limits of the experimental error.
CO3	Determine the various physical parameters for the various problems under study.
CO4	Verify various laws studied in the theory part.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	-	3	-	-	3
CO2	-	3	-	-	3
CO3	-	3	-	-	3
CO4	-	3	-	-	3
CO5	-	3	-	-	3

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Subject Tittle: Chemistry Lab-III
Subject Code: UC-BHCP-208-19

UNIT-I

Preparation and Standardisation of Solutions.

UNIT-II

Surface tension measurements.
a) Determine the surface tension by (i) drop number (ii) drop weight method.
b) Study the variation of surface tension of detergent solutions with concentration.

UNIT-III

Viscosity measurement using Ostwald's viscometer.
a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
b) Study the variation of viscosity of sucrose solution with the concentration of solute.

UNIT-IV

pH metry
a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b) Preparation of buffer solutions of different pH;
(i) Sodium acetate-acetic acid
(ii) Ammonium chloride-ammonium hydroxide
c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d) Determination of dissociation constant of a weak acid.

Recommended Books

1. J.B. Yadav , Practical Physical Chemistry, Krishna
2. Findlay, Practical Physical Chemistry, Longman, New York

BBA 301-18	Organizational Behaviour	L-5, T-1, P-0	6 Credits
Pre-requisite: Understanding of senior secondary level Physics and Mathematics			
Course Objective: This course emphasizes the importance of human capital in the organizations of today. It gives an insight to the students regarding individual and group behaviour in any organization.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	To explain the basics of Orgnaizational behaviour and various challenges for OB
CO2	To illustrate the foundations of Individual Behaviour and various factors influencing individual behaviour viz. learning, personality, perception, attitude and motivation.
CO3	To examine the dynamics of group development and group properties.
CO4	To understand various dimensions of organisational culture.
CO5	To analyse the process of conflict management and approaches to stress management.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	-	3	-	-	3
CO2	-	3	-	-	3
CO3	-	3	-	-	3
CO4	-	3	-	-	3
CO5	-	3	-	-	3

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Course Title: Organizational Behaviour
Course Code: BBA 301-18

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UNIT-I

Introduction: Meaning of organizational behaviour and its relevance in today's business environment, contributing disciplines to Organization Behaviour, challenges and opportunities for OB.
Individual behaviour in organization: Foundations of individual behaviour, Factors influencing Individual Behaviour.
Learning: Meaning, characteristics and theories: Classical conditioning theory, operant conditioning theory, social learning theory, behaviour modification.

UNIT-II

Perception: Nature, importance, perceptual process, factors influencing perception, perceptual errors.
Attitude: Meaning, importance, components and types of work related attitude.
Personality: Meaning, determinants of personality, personality traits.
Motivation: Meaning, types of motivation, theories of work motivation given by Maslow, Herzberg, McGregor, Vroom and Porter – Lawler.

UNIT-III

Group behaviour in organization: Group dynamics, Types of groups, Group development, theories of group development, Group norms and roles, Group cohesiveness,
Work Teams: Meaning, characteristics, types of team, Creating effective team.
Leadership: nature, leadership styles, Leadership theories: trait theory and behavioural theories.

UNIT-IV

Conflict Management: Meaning, types and sources of conflict, Process of conflict management, approaches to conflict management.
Stress management: sources of stress, approaches for stress management.
Organizational culture: meaning, concept, types of culture, dimensions of organizational culture.

Recommended BOOKS:

1. Robbins, Organization Behaviour, Pearson Education Asia
2. Luthans, Organization Behaviour, Tata McGraw Hill
3. Newstrom, Organizational Behaviour: Human Behaviour at Work, Tata McGraw Hill
4. L.M. Prasad, Organisation Behaviour, Sultan Chand
5. Parikh, Gupta, Organisational Behaviour, Tata McGraw Hill
6. Aswathappa, Organization Behaviour, Himalaya.

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SEMESTER-IV

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UC-BSHM-401-19	Vector Calculus	L-4, T-1, P-0	5 Credits

Pre-requisite: Students must have the knowledge of Scalar, Vectors and vector algebra.

Course Objectives: The objective of the course on **Vector Calculus** is to equip the B.Sc. (Hons) students with the theoretical as well as physical interpretations of scalar vector quantities. Their applications in real life engineering problems. Furthermore, students will be introduced to more general concept, that is, Tensors.

Course Outcomes: At the end of the course, the student will be able to

CO1	Learn the basic concepts of Vector algebra, Dot product, Cross product.
CO2	Learn about operations on vectors, such as, vector triple product, scalar triple product.
CO3	Understand the Differentiation of Vector valued functions, Scalar valued functions, gradient, Divergence and curl.
CO4	Be acquainted with Line, Surface and Volume integrals of vector (or scalar) valued functions. And, Gauss, Divergence and Stokes theorem, Tensors.
CO5	Apply the learnt techniques in solving various problems related to vectors.

Mapping of course outcomes with the program outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	1
CO5	2	2	2	2	1

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Course Title: Vector Calculus
Course Code: UC-BSHM-401-19

UNIT-I

Vector Algebra: Dot and Cross product of two vectors, Scalar and vector product of three vectors. Scalar fields and vector fields. [Ref 2: Chapter-1B]
Introduction to Suffix notation and summation convention, Kronecker delta.

UNIT-II

Vector Differentiation: Vector functions, Differentiation of a vector function, General rules for differentiation of vector function, Chain rule, Geometric interpretation of $\frac{d\vec{r}}{dt}$, Velocity and acceleration, Scalar and vector point function. [Ref 2: Chapter-1C]

UNIT-III

Gradient, divergence and Curl: Vector Differential operator, Gradient of a scalar function, Geometric interpretation of Gradient, Directional Derivative, Properties of Gradient, Divergence of a Vector point function, Physical interpretation of Divergence, Curl of Vector point function, Physical interpretation of curl, Properties of divergence and curl, Repeated operations by ∇, Conservative vector field and Scalar Potential. [Ref 2: Chapter-1C]

UNIT-IV

Vector Integral Calculus: Introduction to Integration of vector functions, Line integral, Surface integral, Volume integral.
Integral Theorems: Green's theorem in the plane, Stoke's Theorem, Gauss' theorem of Divergence and their applications. [Ref 2: Chapter-1D]

RECOMMENDED BOOKS:

1. M. Spiegel, S. Lipschutz and D. Spellman, Vector Analysis and An Introduction to Tensor Analysis, 2nd Edition. U.K.: Schaum's Outline Series, McGraw Hill, 1980.
2. H. Anton and C. Rorres, Elementary Linear Algebra, New Delhi: Wiley, 2012.
3. P. C. Mathews, Vector Analysis, 2nd Indian reprint. Springer undergraduate Mathematics Series, Springer-Verlag London, 2008.
4. H. Lass, Vector and Tensor Analysis. McGraw Hill, 2007.
5. S. Narayan, Tensor Analysis. New Delhi: S. Chand, 2010.

UC-BSHM-402-19	**Ordinary Differential Equations**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Calculus

The Objective of this course is to introduce ordinary differential equations and basic theory of existence and uniqueness of solutions. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations appearing in various fields of science and technology.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the basic definitions to know about ordinary differential equations, its various types and their solutions
CO2	Visualize the geometrical meaning of first order differential equation.
CO3	Understand the fundamental concepts about existence and uniqueness of solution of initial value problem
CO4	Understand the applications of differential equations in different type of phenomenon.
CO5	Apply power series method to obtain series solutions of differential equations

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	3	-	-	3
CO2	2	3	-	-	3
CO3	2	3	-	-	3
CO4	2	3	-	-	3
CO5	2	3	-	-	3

Course Title: Ordinary Differential Equations
Course Code: UC-BSHM-402-19

UNIT-I

Basic definitions, Formulation of differential equations, order and degree of differential equation, primitives, initial value problem and solution of differential equations, First order differential equations: Linear, non-linear differential equations, Solution by variables separable, homogeneous, non-homogeneous exact equations, reducible in exact form and integrating factors, Solution of Leibnitz and Bernoulli's differential equation.

UNIT-II

Geometrical interpretation of first order differential equation, Successive approximation, Existence and uniqueness of solution of first order differential equations, Lipschitz condition, Picard's existence and uniqueness theorem.

UNIT-III

First order and higher degree equations solvable for x, y, p and Clairaut's form, Linear differential equations of first and higher order with constant coefficients, exponential decay model, lake pollution model (case study of Lake Burley Griffin), exponential growth of population (Scope as in Chapters 1, 3 of S. L. Ross).

UNIT-IV

Linear differential equations with variable coefficients, Cauchy's Euler equation and Legendre's equation, Linear independence, Linear dependence, Wronskian, Variation of parameters method.

RECOMMENDED BOOKS

1. S.L. Ross, Differential Equations, 3rd edition, John Wiley and Sons, 2004
2. W. E. Boyce and R. C. Diprima, 4th edition, Elementary differential equations and boundary value problems, John Wiley and Sons,1986.
3. M.D. Raisinghania, Ordinary and Partial Differential Equations, S Chand Publisher,15th edition, 2013
4. E. A. Coddington, An introduction to ordinary differential equation, Prentice- Hall of India.

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UC-BSHM-403-19	Linear Algebra	L-4, T-1, P-0	4 Credits
Pre-requisite: - Sets, Relations and Functions			
Course Objectives: This course is designed to introduce the basic concepts of linear algebra *viz.* vector spaces, linear transformation and eigenvalue problem etc. The main focus of the course will be on theoretical foundation of these concepts including explanation through examples.			
Course Outcomes: At the end of the course, the students will be able to			
CO1	Deal with the notions of vector spaces and linear transformations.		
CO2	Demonstrate matrix representation of linear transformation.		
CO3	Deal with the eigenvalue and eigenvector problem arising in different fields of applications, for instance, in solution of system of linear differential equations and stability of numerical methods etc.		
CO4	Diagonalize a given matrix using the eigenvalues and eigenvectors of the corresponding matrix.		
CO5	Demonstrate similarity of matrices and use of a method to check similarity of two matrices.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	-	-	1
CO2	3	3	-	-	1
CO3	2	3	-	-	1
CO4	2	3	-	-	1
CO5	2	3	-	-	1

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Course Title: Linear Algebra
Course Code: UC-BSHM-403-19

UNIT-I

Vector spaces, subspaces, span of a set, intersection and union of subspaces, direct sum of subspaces, linear dependence and independence of vectors, basis and dimension of a vector space, finite dimensional vector spaces.

UNIT-II

Linear transformations, matrices as linear transformations, kernel and image of linear transformation, rank and nullity of a linear transformation, Rank-Nullity theorem, inverse of a linear transformation,

UNIT-III

Singular and non-singular linear transformations, isomorphism, algebra of linear maps, composition of linear maps, Matrix representation of a linear transformation, properties of matrix representation, change of basis.

UNIT-IV

Polynomials of matrices, characteristic polynomial, eigenvalues and eigenvectors, properties of eigenvalues and eigenvectors, Cayley-Hamilton theorem and its applications, similarity of matrices, diagonalization of a matrix, quadratic forms, minimal polynomial.

RECOMMENDED BOOKS

1. Serge Lang, Introduction to Linear Algebra, 2nd Edition, Springer, 1997.

2. D. C. Lay, S. R. Lay, J. J. McDonald, Linear Algebra and its Applications, 5th Edition, 2014.

3. V. Krishnamurthy, V. P. Mainra, J. L. Arora, Introduction to Linear Algebra, East-West Press, 1976.

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UC-BSHM-404-19	Probability and Statistics	L-4, T-1, P-0	4 Credits

Pre-requisite: - Basic statistics, Permutation & combination and the basic knowledge of probability at 10+2 level.

Course Objectives: The objective of the course is to prepare students for big data analysis by introducing basic concepts of statistics and probability theory along with their applications.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the measures of central tendency, the concepts like skewness and standard deviation of the data.
CO2	Correlate bivariate and multivariate data.
CO3	Fit the curve by collecting random data and understand regression lines.
CO4	Understand the mathematical definition of probability, conditional probability and its applications.
CO5	Understand the theoretical concepts like random variable, probability distribution, generating functions and their usage.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	1	3	-	-	3
CO2	1	3	-	-	3
CO3	2	3	-	-	3
CO4	2	3	-	-	3
CO5	3	3	-	-	3

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Subject Title: Probability and Statistics

Code: UC-BSHM-404-19

UNIT-I

Measure of central tendency, Measure of dispersion, Coefficient of variation, relation between measure of dispersion, Standard deviation of the combination of two groups, Moments, Skewness, Kurtosis. Correlation, Rank correlation.

UNIT-II

Curve fitting, graphical method, laws reducible to linear law, Principle of least squares, Method of least square, Fitting of $y=ax^n$, $y=ae^{bx}$, $xy^n=b$; method of group averages, fitting a parabola, method of moments, Regression, lines of regression.

UNIT-III

Definition of probability, probability and set notations, Addition law of probability, Independent events-Multiplication law of probability, Baye's theorem

UNIT-IV

Random variable, discrete probability distribution, continuous probability distribution, expectation, variance, moments, moment generating function, probability generating function.

RECOMMENDED BOOKS:

1. S.C. Gupta and V.K. Kapoor, Mathematical Statistics.
2. Olive Jean Dunn, Virginia A. Clark, Basic Statistics, John Wiley & Sons, Inc., Publication.

EVS-101A	**Environmental Studies**	**L-2, T-0, P-0**	**2 Credits**
Pre-requisites (if any): NA			
Course Objectives: The aim and objective of this course is to teach the fundamental concepts of Environment as a whole along with Natural Resources, their types, and issues related with sustainable use as its components along with social issues related with environment.			
Course Outcomes: At the end of the course, the student will be			
CO1	Understand the fundamental concepts about Environment and its components.		
CO2	Know about various types of natural resources, their functions, uses, exploitation and the problems arise due to these along with suitable case studies.		
CO3	Gain knowledge about working of various ecosystems, their features and functions and energy flow through them.		
CO4	Know about biodiversity, its various forms, importance and important areas		

Mapping of course outcomes with the program outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	3	-	-	3
CO2	1	2	-	-	3
CO3	1	3	-	-	3
CO4	1	2	-	-	3

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Course Tittle: Environmental Studies
Course Code: EVS-101A

UNIT-I

Multidisciplinary nature of environmental studies, Definition, scope and importance, Need for public awareness. (2)

UNIT-II

Natural Resources : Renewable and non-renewable resources : Natural resources and associated problems.
a) Forest resources : Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
b) Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
c) Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
d) Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
e) Energy resources : Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies.
f) Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification.
• Role of an individual in conservation of natural resources.
• Equitable use of resources for sustainable lifestyles. (10)

UNIT-III

Ecosystems
• Concept of an ecosystem.
• Structure and function of an ecosystem.
• Producers, consumers and decomposers.
• Energy flow in the ecosystem.
• Ecological succession.
• Food chains, food webs and ecological pyramids.
• Introduction, types, characteristic features, structure and function of the following ecosystem :-
a. Forest ecosystem
b. Grassland ecosystem
c. Desert ecosystem
d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) (8)

UNIT-IV

Biodiversity and its conservation
• Introduction – Definition : genetic, species and ecosystem diversity.
• Biogeographical classification of India
• Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values
• Biodiversity at global, National and local levels.
• India as a mega-diversity nation
• Hot-spots of biodiversity.
• Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts.
• Endangered and endemic species of India
• Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity (6)

RECOMMENDED BOOKS

1. K.C. Aggarwal, Environmental Biology, Nidi Publishers, 2001
2. E.P. Odum, Fundamentals of Ecology, WB Saunders, 1971
3. Erach Bharucha, The Biodiversity of India, Mapin Publishers, 2003
4. Benny Joseph, Environmental Studies, McGraw Hills, 2015.
5. R Rajagopalan, Environmental Studies, Oxford Higher Education, 2016.
6. S.P. Misra & S.N. Pandey, Essential Environmental Studies, Ane Books Pvt. Ltd. 2016

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UC-BSM-501-19	**Real Analysis-II: Metric Spaces and Reimann Integration**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Differential and Integral Calculus, Basic set theory

Course Objectives: The objectives of this course are to:

1. Develop understanding of abstract mathematical concepts.
2. Develop analytical and logical skills of students.
3. Introduce to students the basic theorems of real analysis
4. Prepare students for the study of advanced analysis.
5. Develop understanding of Reimann integrable functions and their properties.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the basic concepts of Real Analysis.
CO2	Visualize abstract mathematical concepts
CO3	Understand basic theorems related to real analysis.
CO4	Understand the logical concepts and apply the knowledge to derive the basic results.
CO5	Understand the behavior of Reimann integrable functions.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	5	-	-	-	4
CO2	5	-	-	-	-
CO3	5	-	-	-	-
CO4	5	3	-	-	5
CO5	-	5	-	-	4

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Course Title: Real Analysis-II

Course Code: UC-BSHM-501-18

UNIT-I

Metric spaces: open sets, closed sets, limit points, interior of a set, closed set, dense and nowhere dense sets, exterior, frontier and boundary points and their properties, balls and bounded sets, limits and continuity (Definition and basic examples only of all above concepts). Sequences in metric spaces, convergent and Cauchy sequences, Complete Metric Spaces (Scope as in ref. 6, Chapter 1, section-1.2, 1.3, 1.4 definition and examples with propositions 1.4.1, 1.4.3 and 1.4.7 / ref.5 section 8.1.10-8.1.18 and sec.8.2).

UNIT-II

Compact sets in a metric space, Heine Borel theorem, sequential compactness, Bolzano Weierstrass property, finite intersection property, continuity and compactness, separable sets, (Scope as in ref. 6, Chapter 5, Theorems 5.1.1-5.1.10, 5.1.14-5.1.15 only). Connectedness, connected subsets of reals, continuity and connectedness. (Basic definitions and fundamental theorems only: Scope as in ref. 6, Chapter 4, Theorems 4.1.3 to 4.1.11 only)

UNIT-III

Riemann Integration, Upper and Lower Darboux Sums, Riemann Sums and definition of Riemann integral through Riemann sums, Cauchy Criterions for integrability, Equivalence of two definitions. The Class of Riemann integrable functions, Properties of the Riemann integral, Fundamental theorems of Calculus. Scope as in Ref 2. Chapter 6 (Art. 32.1 to 32.9, 33.1, 33.2, 33.3, 33.4 to 33.8, 33.9, 34.1, 34.3)

UNIT-IV

Improper Integrals, Tests for Convergence of Improper Integrals, Beta and Gamma functions.

Scope as in Ref. 3 Chapter 11 and ref. 2, 8.17 to 8.20.

Text Books

1. T. M. Apostol, Mathematical Analysis, 2nd Edition, Narosa Publishing House, Reprint 2002.
2. K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
3. S. C. Malik and Savita Arora, Mathematical Analysis, 3rd Edition, New Age International Publishers, 2008.
4. Shanti Narayan, A Course of Mathematical Analysis, S. Chand and Company Ltd.1984.
5. William F.Trench, Introduction to real Analysis, Trinity University, San Antonio, Texas, USA, (Open Book Initiative of American Institute of Mathematics)

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6. Satish Shirali, Harkishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.

Reference Books

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
2. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
3. M. H. Protter and C. B. Morrey, A First Course in Real Analysis, 2nd Edition, Springer Verlag, Indian Reprint, 2004.
4. W. Rudin. Principles of Mathematical Analysis, 3rd edition. McGraw Hill, 1976.
5. N. L. Carothers, Real Analysis, Cambridge University Press 2000.

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UC-BSM-502-19	Algbera-II	L-4, T-1, P-0	4 Credits
Pre-requisite: Sets, Relations and Functions			

Course Objectives: The objectives of this course are to:

1. Develop understanding of axiomatic algebraic structures.
2. Develop analytical and logical skills of students.
3. Introduce basic algebraic structures: Groups and Rings.
4. Prepare students for the study of advanced abstract algebra.
5. Deal with axiomatic structures occurring in science and engineering.

Course Outcomes: At the end of the course, the students will be able to

CO1	Deal with different algebraic structures occurring in abstract algebra.
CO2	Analyze algebraic structure Group and its properties.
CO3	Analyze algebraic structure Ring and its properties.
CO4	Apply the knowledge of abstract mathematics in studying advanced pure mathematics.
CO5	Apply the methods of proofs in proving theoretical results in other branches, for example, in science and engineering.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	5	-	-	-	5
CO2	5	-	-	-	5
CO3	5	-	-	-	5
CO4	5	-	-	-	5
CO5	5	-	-	-	5

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Course Title: Algebra-II

Course Code: UC-BSHM-502-18

UNIT-I

Binary operations, symmetries of a square, Groups, semi groups, quaternion groups, groups of integers modulo n, symmetric groups, cyclic notation for permutations, even and odd permutations, properties of permutations, elementary properties of groups.

UNIT-II

Subgroups and examples of subgroups, center of a group, centralizer, normalizer, cosets, Lagrange's theorem on finite groups, index of a subgroup, product of two subgroups, Cyclic groups and their properties.

UNIT-III

Normal subgroups, simple subgroup, quotient group, Group homomorphisms, properties of homomorphism, properties of isomorphism, First, second and third isomorphism theorems, Dihedral group, permutation groups, Cayley's theorem.

UNIT-IV

Definitions and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring, Ideals, sum and product of ideals.

Textbooks

1. V. K. Khanna, S. K. Bhambri, A Course in Abstract Algebra, 4th Ed., Vikas Publishing House, 2013.
2. John B. Fraleigh, Neal E. Brand, A First Course in Abstract Algebra, 8th Ed., Pearson, 2021.

Reference Books

1. M. Artin, Algebra, 2nd Ed., Pearson, 2011.
2. Joseph A. Gallian, Contemporary Abstract Algebra, 8th Ed., Cengage, 2013.

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UC-BSM-503-19	**Numerical Methods**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Differential and Integral Calculus			

Course Objectives: The objectives of this course are to:

1. Introduce numerical methods for solving continuous problems which are difficult to deal with analytically.
2. Develop analytical and computational skills of students.
3. Introduce methods to deal with nonlinear equations, system of linear algebraic equations.
4. Introduce methods for constructing interpolating polynomials.
5. Introduce methods to deal with numerical differentiation, numerical integration and ordinary differential equations.
6. Develop understating of computational mathematics and also to demonstrate its importance in science and engineering.

Course Outcomes: At the end of the course, the students will be able to

CO1	Find approximate numerical solutions of nonlinear equations and system of linear algebraic equations.
CO2	Develop and use interpolating polynomials when explicit form of the function of interest is not known or complicated to deal with.
CO3	Deal with differentiation and definite integral problems approximately when it is difficult to get exact evaluation of these.
CO4	Apply the numerical methods for solving ordinary differential equations when it is difficult to deal with them analytically.
CO5	Apply the understanding of computational techniques in dealing with real world problems occurring in science and engineering.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	4	-	-	5
CO2	3	5	-	-	5
CO3	3	4	-	-	5
CO4	3	4	-	-	5
CO5	3	3	-	-	5

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Course Title: Numerical Methods

Course Code: UC-BSHM-503-18

UNIT-I

Computer representation of numbers, scientific notation, accuracy of numbers, errors and its different types, estimation of errors, propagation of errors, the concepts of stability and condition number. Polynomial and transcendental equations: Bisection method, Newton-Raphson's method, Secant method, Regula-Falsi method, General iteration method, Rate of convergence.

UNIT-II

System of linear algebraic equations, Gaussian elimination method, Gauss-Jordan method. Iterative methods: Gauss Jacobi method, Gauss-Seidel method and their convergence analysis. Interpolation, Lagrange interpolation, Newton's divided difference interpolation, Newton's forward and backward difference interpolation formulas.

UNIT-III

Numerical differentiation: methods based on finite differences. Numerical integration: idpoint rule, Trapezoidal rule, Simpson's rule, Simpson's $\frac{3}{8}$-rule, Boole's rule, composite trapezoidal rule, composite Simpson's rule.

UNIT-IV

Ordinary differential equations, Euler's method, Taylor series method, Runge-Kutta methods, linear multi-step methods: Adams-Bashforth methods and Adams-Moulton methods.

Textbooks

1. M. K. Jain. S. R.K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, 7th Ed., 2019.
2. Richard L. Burden and J. Douglas Faires, Numerical Analysis, 9th Edition, Cengage Learning, 2012.

Reference Books

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, 2007.
2. K. E. Atkinson, An Introduction to Numerical Analysis, 2nd Ed., Wiley, 1989.

UC-BSM-504-19	Partial Differential Equation (PDE)	L-4, T-1, P-0	4 Credits

Pre-requisite: Calculus of several variables and ODE

Course Objectives: The objectives of this course are to:

1. Introduce Partial differential equations and different methods to solve it.
2. Derive heat and wave equations.
3. Find the solutions of PDEs with boundary conditions.
4. Learn the technique of separation of variables to solve PDEs and analyze the behavior.
5. Develop the skills that will allow students to work effectively with the concepts.

Course Outcomes: At the end of the course, the students will be able to

CO1	Solve linear partial differential equations of both first and second order.
CO2	Classify the Partial differential equations.
CO3	Apply problem-solving using concepts and techniques from PDE's and Fourier analysis applied to diverse situations in physics, engineering and in other mathematical contexts.
CO4	Demonstrate accurate and efficient use of Fourier analysis techniques and their applications in the theory of PDE's.
CO5	Solve real problems by identifying them appropriately from the perspective of partial derivative equation.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**5**	-	-	-	**5**
CO2	**5**	-	-	-	**5**
CO3	**5**	-	-	-	**5**
CO4	**5**	-	-	-	**5**
CO5	**5**	-	-	-	**5**

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Course Title: Partial Differential Equations (PDE)

Course Code: UC-BSHM-504-18

UNIT-I

Introduction of a PDE, Surfaces and Normals, Formation of PDE, Solution of PDE of first order, Lagrange's method, Integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces. Non-linear partial differential equation of the first order, Cauchy method of characteristics, compatible systems of first order equations, Charpit's method.

UNIT-II

Classification of a second order PDE, Elliptic equations: Derivation of Laplace equation, Boundry value problems, Method of separation of variables, Solution of Laplace equation in cylindrical and spherical coordinates.

UNIT-III

Parabolic differential equations: Occurrence of diffusion equation, Boundary conditions, Solution by separation of variables method, Solution of diffusion equation in cylindrical spherical coordinates.

UNIT-IV

Hyperbolic differential equation: Derivation of one - dimensional wave equation, vibrating string-variables separation solution, Periodic solution of one - dimensional wave equation in cylindrical and spherical polar coordinates.

Books Recommended:

1. K. Sankara Rao, Introduction to Partial differential Equations (Second Edition), PHI.
2. Walter A. Strauss, Partial differential equations An Introduction, John Wiley and Sons.
3. Sneddon I. N, Elements of Partial differential equations, Dover Publications, Inc. Newyork, 2006.
4. Ross S. L, Differential equation. 3rd Ed., John Wiley and Sons, India, 2004.

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UC-BSHM-601-19	Number Theory	L-4, T-1, P-0	4 Credits

Pre-requisite: Numbers system and Basic operations on numbers.

Course Objectives: The objectives of this course are to:

1. Introduce the fundamental concepts of the Number theory
2. Develop understanding of the fundamental concepts of Number theory such as Fundamental theorem of arithmetic, congruences etc.
3. Develop the skills that will allow students to apply the concepts in real life problems.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand well ordering principle, Archimedean Property, Binomial theorem, Triangular number
CO2	Describe basic properties of GCD and LCM and having the ability to compute them.
CO3	Decide the primality of a given number and be able to understand the concept of infinite primes.
CO4	Apply Chinese remainder theorem.
CO5	Understand the utility of Divisibility tests.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	3
CO2	3	2	2	2	3
CO3	3	2	2	2	3
CO4	2	3	2	2	3
CO5	3	2	2	2	3

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Course Title: Number Theory

Course Code: UC-BSHM-601-19

UNIT-I

Earlier Number Theory: Well ordering Principle, Archimedean Property, Principle of finite induction, Binomial theorem, Triangular number, Sum, difference, and product of triangular numbers.

UNIT-II

Divisibility Theory: division Algorithm, Greatest common divisor (GCD) and its properties, Euclid's Algorithm, Least common multiplier and its properties, Relation between GCD and LCM, Linear Diophantine equations and their solutions.

UNIT-III

Primes and their Distribution: Fundamental theorem of arithmetic, irrational numbers, Sieve of Eratosthenes to check the primality, Golbach conjecture, Euclid's Infinite prime number theorem, Product of consecutive 'r' integers.

UNIT-IV

Theory of Congruences: Basic properties of congruences, Special divisibility tests, Linear congruences and their incongruent solutions, Chinese remainder theorem.

RECOMMENDED BOOKS:

1. David M. Burton, Elementary Number Theory, 7th Ed., Tata McGraw-Hill, 2007, Print.
2. Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., 2007. Print.

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UC-BSM-602-19	Complex Analysis	L-4, T-1, P-0	4 Credits

Pre-requisite: Complex numbers system and Calculus of several variables.

Course Objectives: The objectives of this course are to:

1. Introduce the fundamental ideas of the functions of complex variables
2. Develop understanding of the fundamental concepts of Complex Analysis such as analytic functions, complex integrals etc. and
3. Learn the technique to solve the problems using Cauchy's theorem, Cauchy's integral formula etc.
4. Develop the understanding to solve the problems of Contour Integration.
5. Develop the skills that will allow students to work effectively with the concepts.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand Complex functions, Its continuity and differentiability.
CO2	Describe basic properties of complex integration and having the ability to compute such integrals.
CO3	Decide when and where a given function is analytic and be able to find its series development.
CO4	Apply residue theorem to compute the several kinds of real integrals.
CO5	Understand the concept of conformal transformation and bilinear transformation.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	**5**	-	-	-	**5**
CO2	**5**	-	-	-	**5**
CO3	**5**	-	-	-	**5**
CO4	**5**	-	-	-	**5**
CO5	**5**	-	-	-	**5**

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Course Title: Complex Analysis

Course Code: UC-BSHM-602-18

UNIT-I

Function of complex variables, limit, continuity and differentiability. Analytic functions, Harmonic functions, Cauchy - Riemann equations (Cartesian and Polar form), sufficient condition for differentiability, Construction of analytic functions.

UNIT-II

Curves, simply closed curves, Complex line integral, Path independence of a line integral, Cauchy's theorem, Cauchy's integral formula and Applications. Liouville's theorem and its consequences.

UNIT-III

Taylor's theorem, Laurent's theorem and their examples. Zeros and singularities of an analytic function, Residue at a pole and at infinity, Cauchy's Residue theorem.

UNIT-IV

Evaluation of definite integrals, Integration round the unit circle, Evaluation of the integral of the form $\int_{-\infty}^{\infty} f(x)dx$, Jordan's Inequality, Jordan's lemma , Integral of the form $\int_{-\infty}^{\infty} \frac{P(x)}{Q(x)} \sin mx\, dx$ etc.

Books Recommended:

1. Copson, E. T.: Theory of functions of complex variables. Oxford university press.
2. Grewal, B.S.: Higher Engineering Mathematics, Khanna Publishers.
3. Conway, J. B. : Functions of one complex variable(Second Edition), Springer.
4. Brown J. W. and Churchill R. V. : Complex variables and applications (Eighth Edition) Mcgraw-Hill Higher Education.
5. Kasana, H.S : Complex-Variable , Theory and Applications, PHI.
6. Ponnusamy S: Foundations of Complex Analysis, Narosa Publishing House.

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UC-BSM-603-19	Mechanics	L-4, T-1, P-0	4 Credits

Pre-requisite: Sets, Relations and Functions

Course Objectives: The objectives of this course are to:

1. Develop understanding of concept of force, coplanar, concurrent forces, their resultant.
2. Develop concept of static equilibrium and the governing laws of equilibrium.
3. Introduce the concept of Friction, kinds of friction and its laws.
4. Develop understanding of the basic laws of mechanics governing the motion of the particle.
5. Introduce the law of energy and its principles.
6. Develop understanding for solving real life mechanics problems related to science and engineering.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the system of different forces and its effect on the physical body.
CO2	Understand the various concepts of statics and dynamics.
CO3	Understand the various mathematical laws of mechanics dealing with the motion of the particle and the static equilibrium.
CO4	Apply the knowledge of Mechanics in solving real life problems related to mechanics.
CO5	Visualize the real life mechanical problems related to science and engineering and frame the mathematical problems along with suggested solutions.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	-	5	-	-	5
CO2	-	5	-	-	5
CO3	3	5	-	-	5
CO4	-	5	-	-	5
CO5	3	5	-	-	5

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Course Title: Mechanics

Course Code: UC-BSHM-603-18

UNIT-I

Concept of Force and the system of forces, Resultant of the Force system, Coplanar and concurrent force system and their resultant, resolution and composition of forces, turning effect of forces, resultant of coplanar non-concurrent force system, funicular polygon, concept of equilibrium, possible displacements of a body, conditions of equilibrium for coplanar force system, body constraints and free body diagrams, reactions.

UNIT-II

Gravity and gravitational force, centre of gravity, centroid, Location of centre of gravity of solids, location of centre of gravity through method of integration, Friction, laws of friction, coefficient of friction, moment of frictional force, rough inclined plane.

UNIT-III

Motion of particles, rectilinear motion of particles, curvilinear motion of particles, kinematics of rigid bodies, Newton's laws of motion, equation of motion, linear momentum of particle, impulse and momentum, conservation of linear momentum, D'Alembert's Principle, circular motion.

UNIT-IV

Work, energy their Principles and applications to rigid bodies undergoing rectilinear and curvilinear translations. Applications of work and energy principle to bodies undergoing rotation about a fixed axis, potential energy, conservation of energy, power.

Textbooks

1. M. M. Malhotra, R. Subramanian, P. S. Gahlot, B. S. Rathore: Textbook in Applied Mechanics, New Age International, 2003.

Reference Books

1. Dynamics by A. S. Ramsey, Cambridge University Press.
2. The Elements of Statics and Dynamics: Part 2 (Dynamics) by S. L. Loney, Arihant Prakashan, Meerut.

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UC-BSHM-604-19	Discrete Mathematics	L-4, T-1, P-0	4 Credits

Pre-requisite: Numbers system and Primality.

Course Objectives: The objectives of this course are to:

1. Introduce the basic ideas of sets, relations and functions.
2. Develop understanding of the fundamental concepts of Basic Counting principles.
3. Develop the skills that will allow students to work effectively with the concepts.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand sets, relations, and functions.
CO2	Describe basic properties of graph theory.
CO3	Decide when and where a given function is one-one, onto.
CO4	Apply logics for inferences.
CO5	Understand the applicability of basic counting principles in daily life problems.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	3
CO2	3	2	2	2	3
CO3	3	2	2	2	3
CO4	2	3	2	2	3
CO5	3	2	2	2	3

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Course Title: Discrete Mathematics

Course Code: UC-BSHM-604-19

UNIT- I

Set Theory, Relations and Functions: Sets, Algebra of Sets, Ordered Sets, Subsets, Relations, Equivalence Relations and Partitions, Hasse diagram, Functions, Composition of Functions, One-One, onto and Inverse of a function Number of one-one functions.

UNIT-II

Basic Counting Principles and Recurrence Relations: Permutation, Combinations, Pigeonhole Principle, Inclusion-exclusion Principle, Recurrence Relations, Characteristic Equation, Homogeneous and non-homogeneous linear recurrence relations with constant coefficients, Generating Functions for some standard sequences.

UNIT-III

Graphs Theory and Basic Terminology: Simple graphs, Multiple graphs, Connected graphs, Complete graphs, Handshaking Theorem, Isomorphism of Graphs, Walks, Paths, Circuits, Eulerian and Hamiltonian Paths, Planar and Non Planar Graphs, Shortest path, Directed graphs, Travelling Salesman Problem.

UNIT-IV

Logic and Boolean algebra: Propositions, Basic logic operators, Logic equivalence involving Tautologies and Contradiction, Conditional Propositions, Quantifiers, Introduction to Boolean algebra, Laws of Boolean algebra, Boolean function, Sum of product form, Logic gates and circuits.

RECOMMENDED BOOKS:

1. K. H. Rosen, Discrete Mathematics and its Applications, 6th Edition, McGraw Hill, 2007.
2. S. Lipschutz and M. L. Lipson. Schaum 's Outline of Discrete Mathematics, Schaum 's Outlines, 2007. Print.
3. B. Ram, Discrete Mathematics. Pearson Publications, 2011. Print.
4. C. L. Lui, Elements of Discrete Mathematics. McGraw Hill, International Edition, Computer Science Series.1986. Print.
5. J.P. Trembley and R.P. Manohar, Discrete Mathematical Structures with Applications to Computer Science. McGraw Hill, 1975. Print.

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UC-BSHM-605-19	**Integral Equations and Integral Transforms**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Differential and Integral Calculus

Course Objectives: The objectives of this course are to:

1. Develop understanding of Integral equations occurring in science and engineering.
2. Introduce Integral Transforms: Laplace Transform and Fourier Transform and also to demonstrate their applications.
3. Develop understanding of applicable mathematics.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the significance of Integral equations
CO2	Solve Integral equations and apply the knowledge to real world problems.
CO3	Apply Laplace transform for solving certain differential equations.
CO4	Apply Fourier transform for solving certain differential equations.
CO5	Apply understanding of applicable mathematics for solving problems occurring in science and engineering.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**3**	**5**	-	-	**5**
CO2	**3**	**5**	-	-	**5**
CO3	**3**	**5**	-	-	**5**
CO4	**3**	**5**	-	-	**5**
CO5	**3**	**5**	-	-	**5**

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Course Title: Integral Equations and Integral Transforms

Course Code: UC-BSHM-605-19

UNIT-I

Integral Equations: Definition of Integral equation, Relation between differential and Integral equations, The Green's function, Conversion of boundary value problems to integral equations using Green's function, solution of integral equations, Integral equations of convolution type, Abel's Integral equation, Integro-differential equations.

UNIT-II

Integral equations (Continue): Integral equations with separable kernels, Solution of Fredholm equations with separable kernels, Solution of Fredholm and Volterra equations by the method of successive approximations.

UNIT-III

Laplace Transform Laplace transform and inverse Laplace transform, sufficient conditions for existence of Laplace transform, linearity property, shifting property, change of scale property, Laplace transform of derivatives and integrals, differentiation of Laplace transform, integration of Laplace transform, convolution theorem, Laplace transform of periodic functions, Solution of initial value problems of ordinary differential equations by Laplace transform.

UNIT-IV

Fourier Transform Fourier transform and its inversion formula, linearity property, shifting property, Modulation theorem, Fourier transform of derivative, Fourier transform of integral, convolution, Fourier cosine transform, Fourier sine transform, Solution of some initial-boundary value partial differential equations using Fourier transform.

Textbooks

1. Francis B. Hildebrand, Methods of Applied Mathematics, Prentice-Hall, INC, 1965.
2. B. S, Grewal, Higher Engineering Mathematics, Khanna Publishers, New Delhi
3. R. K. Jain, S. R. K. Iyengar, Advanced Engineering Mathematics, 5th Ed., Narosa, 2019.
4. Baidyanath Patra, An Introduction to Integral Transforms, 1st Ed., CRC Press, 2018.

Reference Books

Lokenath Debnath, Integral Transforms and Their Applications, 3rd Ed., Chapman and Hall/CRC, 2014.

B.Sc. (Hons.) Mathematics

Course Structure and Syllabus

University Campus

(Based on Choice Based Credit System)

2019 onwards

DEPARTMENT OF MATHEMATICAL SCIENCES

VISION

To be a knowledge nerve center in Mathematics, Pure and Applied Research and industry requirements for creating sustainable infrastructure and enhancing quality of life

MISSION

1. To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Mathematical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation;
2. To develop and conduct continuing education programs for Science graduates with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University;
3. To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit.

B.Sc. (Honours Mathematics) Program

PROGRAM OBJECTIVES

Objectives of the program are to catch young and talented students, motivated to study Mathematics and to nurture them to develop their mathematical reasoning and logics. Other objectives of the program are to inspire students to pursue study in higher mathematics and grow as a skillful mathematician to cater the needs of knowledgeable society.

Duration: B.Sc. (Hons) Mathematics is a graduate level program offered by the Department of Mathematical Sciences. This is a 3-years program, consisting of six semesters with two semesters per year.

Program Code: BSHM (Bachelors of Science (Hons) in Mathematics)

Eligibility: 10+2 in any stream with Mathematics as one of the subjects with at least 50% marks in aggregate.

PROGRAM EDUCATIONAL OBJECTIVES: At the end of the program, the student will be able to:

PEO1	Apply principles of basic science concepts in understanding, analysis and prediction of mathematical systems.
PEO2	Develop human resource with knowledge, abilities and insight in Mathematics and related fields required for career in academia and industry.
PEO3	Engage in lifelong learning and adapt to changing professional and societal needs.

PROGRAM SPECIFIC OUTCOMES

At the end of the program,

PSO1	Students will be able to understand the nature of Mathematics and shall be ready to study higher 'Abstract Mathematics'.
PSO2	Students will be able to visualize the importance of Mathematics and apply the knowledge of Mathematics in Physical, Chemical and Social Sciences.
PSO3	Students will be able to use latest mathematical tools and software.
PSO4	Students will be able to formulate computer codes to tackle the complex mathematical problems.
PSO5	Students will become more confident due to enhanced level of reasoning, logics, skills and shall be able to understand the needs of the society.

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Understand the concepts of different branches of Mathematics.
PO2	Demonstrate expertise to conduct wide range of scientific modelling.
PO3	Apply the concepts of mathematics in areas of mechanics, analysis, calculus, algebra, geometry, mathematical modelling etc., in industry, academia, and day-to-day life.

Scheme of the Program:

SEMESTER FIRST **Contact Hrs. 34 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-101-19	Calculus -1	4	1	-	40	60	100	4
2.	UC-BSHM-102-19	Co-ordinate Geometry	4	1	-	40	60	100	4
3.	UC-BSHM-103-19	Programming Lab-I	-	-	4	30	20	50	2
4.*	UC-BSHP-112-19	Electricity and Magnetism	3	1	-	40	60	100	4
	UC-BSHP-113-19	Physics Lab-I	-	-	4	30	20	50	2
	UGCA-1902	Fundamentals of Computer and IT	3	1	-	40	60	100	4
	UGCA-1906	Fundamentals of Computer and IT Laboratory	-	-	4	60	40	100	2
5.**	UC-BHCL-I-101-19	Inorganic Chemistry	3	1	-	40	60	100	4
	UC-BHCP-I-102-19	Chemistry Lab-I	-	-	4	30	20	50	2
	BBA-GE 101	Managerial Economics-I	5	1	0	40	60	100	6
6.	UC-BSHL-105-19	Communicative English -I	2	-	-	20	30	50	2
7.	UC-BSHL-106A/106B-19	Punjabi Compulsory-I/ Mudhli Punjabi-I	2	-	-	20	30	50	2
						Total			26

L:Lectures T: Tutorial P:Practical Cr: Credits

Note 1*: Physics (UC-BSHP-112-19 & UC-BSHP-113-19) and Chemistry (UC-BHCL I-101-19 & UC-BHSP-I-102-19) are compulsory for the Students with Non-Medical background.

Note 2: Students without Non-medical background may opt Fundamentals of Computer and IT (UGCA-1902 & UGCA-1906) and Managerial Economics-I (BBA-GE-101).**

SEMESTER SECOND **Contact Hrs. 34 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-201-19	Calculus-II	4	1	-	40	60	100	4
2.	UC-BSHM-202-19	Solid Geometry	4	1	-	40	60	100	4
3.	UC-BSHM-203-19	Programming Lab-II	-	-	4	30	20	50	2
4.*	UC-BSHP-124-19	Waves and Vibrations	3	1	-	40	60	100	4
	UC-BSHP-125-19	Physics Lab-II	-	-	4	30	20	50	2
	UGCA-1909	Object Oriented Programming using C++	3	1	-	40	60	100	4
	UGCA-1910	Object Oriented Programming using C++ Laboratory	-	-	4	60	40	100	2
5.**	UC-BHCL-113-19	Organic Chemistry	3	1	-	40	60	100	4
	UC-BHCP-119-19	Chemistry Lab-II	-	-	4	30	20	50	2
	BBA-GE 201-18	Managerial Economics-II	5	1	0	40	60	100	6
6.	UC-BHHL-115-19	Communicative English -II	2	-	-	20	30	50	2
7.	UC-BHHL-116A/116B-19	Punjabi Compulsory-II/ Mudhli Punjabi-II	2	-	-	20	30	50	2
Total									**26**

L:Lectures T: Tutorial P:Practical Cr: Credits

Note 1*: Physics (UC-BSHP-112-19 & UC-BSHP-113-19) and Chemistry (UC-BHCL-113-19 & UC-BHCP-119-19) are compulsory for the Students with Non-Medical background.

Note 2: Students without Non-medical background may opt Object Oriented Programming using C++ (UGCA-1909 & UGCA-1910) and Managerial Economics-II (BBA-GE-201)**

Scheme of the Program:

SEMESTER THIRD **Contact Hrs. 34 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-301-19	Calculus -III	4	1	-	40	60	100	4
2.	UC-BSHM-302-19	Real Analysis-I	4	1	-	40	60	100	4
3.	UC-BSHM-303-19	Algebra-I	-	-	4	40	60	100	4
4.	UC-BSHM-304-19	Programming Lab-III	-	-	4	30	20	50	2
5.*	UC-BSHP-214-19	Elements of Modern Physics	3	1	-	40	60	100	4
	UC-BSHP-215-19	Physics Lab-III	-	-	4	30	20	50	2
	UGCA1914	Programming in Python	3	1	-	40	60	100	4
	UGCA-1917	Programming in Python Laboratory	-	-	4	60	40	100	2
6.**	UC-BHCL-I-204-19	Physical Chemistry	3	1	-	40	60	100	4
	UC-BHCP-I-208-19	Chemistry Lab-III	-	-	4	30	20	50	2
	BBA-301-18	Organizational Behavior	5	1	0	40	60	100	6
Total									**26**

L:Lectures T: Tutorial P:Practical Cr: Credits

Note 1*: Physics (UC-BSHP-214-19 & UC-BSHP-215-19) and Chemistry (UC-BHCL I-204-19 & UC-BHSP-I-208-19) are compulsory for the Students with Non-Medical background.

Note 2: Students without Non-medical background may opt Programming in Python(UGCA-1914 & UGCA-1917) and Organizational Behavior (BBA-GE-301-18).**

SEMESTER FOURTH **Contact Hrs. 34 Hrs.**

S.No.	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-401-19	Vector Calculus	4	1	-	40	60	100	4
2.	UC-BSHM-402-19	Ordinary Differential Equations	4	1	-	40	60	100	4
3.	UC-BSHM-403-19	Linear Algebra	4	1	-	40	60	100	4
4.	UC-BSHM-404-19	Probability and Statistics	4	1	-	40	60	100	4
5.	UC-BSHM-405-19	Programming Lab-IV	-	-	4	30	20	50	2
6.	UC-BSHM-406-19	Project Work	6	-	-	40	60	100	6
7.	UC-BSHM-407-19	Skill Enhancement Course (Audit)	2	-	-	-	-	-	-
8.	EVS-101A	Environmental Studies	2	-	-	40	60	100	2
Total									**26**

L:Lectures **T: Tutorial** **P:Practical** **Cr: Credits**

Examination and Evaluation

Theory			
S. No.	**Evaluation criteria**	**Weightage in Marks**	**Remarks**
1	Mid term/sessional Tests	24	Internal evaluation (40 Marks) MSTs, Quizes, assignments, attendance, etc., constitute internal evaluation. Average of two mid semester test will be considered for evaluation.
2	Attendance	6	
3	Assignments	10	
4	End semester examination	60	External evaluation
5	Total	100	Marks may be rounded off to nearest integer.
Practical			
1	Evaluation of practical record/ Viva Voice/Attendance/Seminar/ Presentation	30	Internal evaluation
2	Final Practical Performance + Viva-Voce	20	External evaluation
3	Total	50	Marks may be rounded off to nearest integer.

Instructions for Paper-Setter in B. Sc (Hons.) Mathematics

A. Scope

1. The question papers should be prepared strictly in accordance with the prescribed syllabus and pattern of question paper of the University.

2. The question paper should cover the entire syllabus with uniform distribution among each units and Weightage of marks for each question.

3. The language of questions should be simple, direct, and documented clearly and unequivocally so that the candidates may have no difficulty in appreciating the scope and purpose of the questions. The length of the expected answer should be specified as far as possible in the question itself.

4. The distribution of marks to each question/answer should be indicated in the question paper properly.

B. Type and difficulty level of question papers

1. Questions should be framed in such a way as to test the students intelligent grasp of broad principles and understanding of the applied aspects of the subject. The Weightage of the marks as per the difficulty level of the question paper shall be as follows:

i)	Easy question	30%
ii)	Average questions	50%
iii)	Difficult questions	20%

2. The numerical content of the question paper should be upto 40%.

C. Format of question paper

1. Paper code and Paper-ID should be mentioned properly.
2. The question paper will consist of three sections: Sections-A, B and C.
3. Section-A is COMPULSORY consisting of TEN SHORT questions carrying two marks each (total 20 marks) covering the entire syllabus.
4. The Section-B consists of FOUR questions of eight marks each covering Unit I & II of syllabus (Taking two questions from each unit I & II).
5. The Section-C consists of FOUR questions of eight marks each covering Unit III & IV of syllabus (Taking two questions from each unit III & IV).
6. Sub-parts of the questions in Section B and C should be preferred for numerical/conceptual questions.
7. Attempt any five questions from Section-B and Section-C, selecting at least two questions from each of the two sections.

Question paper pattern for MST:

Roll No:	**No of pages:**
IK Gujral Punjab Technical University- Jalandhar	
Department of Mathematical Sciences	
Academic Session:	
Mid-Semester Test: I/II/III (Regular/reappear)	**Date:**
Programme: B.Sc.(Hons.) Mathematics	**Semester:**
Course Code:	**Course:**
Maximum Marks: 24	**Time: 1 hour 30 minutes**

❖ Note: Section A is compulsory; Attempt any two questions from Section B and one question from Section C.

Section: A		**Marks**	**Cos**
1		2	
2		2	
3		2	
4		2	
Section: B			
5		4	
6		4	
7		4	
Section: C			
8		8	
9		8	

Details of Course Objectives

CO1	
CO2	
CO3	
CO4	
CO5	

SEMESTER-I

UC-BSHM-101-19	Calculus-I	L-4, T-1, P-0	4 Credits

Pre-requisite: Elementary calculus of senior secondary level.

Course Objectives: The objectives of this course are to make the students understand the following:

1. The fundamental concepts of differential and integral calculus.
2. The geometrical meaning of functions, limits, continuity, derivatives, mean value theorems.
3. Applications of derivatives and sketching of curves.
4. The definition of Integral calculus and its basic applications.
5. The relation between derivative and the integration of a function.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the basic concepts of Differential and Integral Calculus.
CO2	Visualize all concepts geometrically.
CO3	Sketch curves of the functions intuitively with the help of Differential Calculus.
CO4	Apply the knowledge of Differential and Integral Calculus.
CO5	Understand the fundamental relation between differential and Integral Calculus.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	3
CO2	3	2	2	2	3
CO3	3	2	2	2	3
CO4	2	3	2	2	3
CO5	3	2	2	2	3

Course Title: Calculus-I
Course Code: UC-BSHM-101-19

UNIT-I

Real line, intervals, order properties of real numbers, the least upper bound and the greatest lower bound properties, Archimedean property. Functions, Graphs of functions, Exponential functions, Inverse functions and Logarithmic functions, implicitly defined functions, some special functions, one-one functions, onto functions, composition of functions, limit of a function, calculating limits through limit laws, The precise definition of limit (ε-δ definition), continuity, limit at infinity, asymptotes, continuous functions and classification of discontinuities, uniform continuity.

UNIT-II

Derivative of a function, the derivative as a function, derivatives of polynomials and exponential functions, the product and quotient rules, rates of change in natural and social sciences, derivatives of trigonometric, inverse trigonometric, logarithmic and hyperbolic functions, the chain rule, implicit differentiation, higher derivatives, preliminary transformations, differentiation of determinants.

UNIT-III

Application of derivative: maximum and minimum values, increasing and decreasing functions, mean value theorems, Intermediate value theorems, How derivatives affect the shape of graph, L' Hospital's rule, concavity and convexity, the second derivative test, points of inflexion, Rolle's theorem, Lagrange's theorem, Cauchy's mean value theorem.

UNIT-IV

Higher order derivatives, calculation to the n^{th} derivative, determination of n^{th} derivative of rational functions. The n^{th} derivative of the products of power of sines and cosines, Leibnitz's theorem, the n^{th} derivative of the product of two functions, Maclaurin's theorem, Taylor's theorem.

TEXT BOOKS

1. Shanti Narayan and P. K. Mittal, Differential Calculus, S. Chand, 2015

RECOMMENDED BOOKS:

2. James Stewart, Calculus, 5th Edition, Brooks/Cole(Thomson), 2003.
3. Robert Wrede and Murray R. Spiegel, Advanced Calculus, 3rd Edition, Schaum's Outline Series (McGraw Hill), 2010.
4. Maurice D Weir, Frank R. Giordano and Joel Hass, Thomas' Calculus, 11th Edition, Pearson, 2008.
5. N. Piskunov, Differential and Integral Calculus, Mir Publishers, Moscow (CBS Publishers & Distributors, India), 1996.

UC-BSHM-102-19	Co-ordinate Geometry	L-4, T-1, P-0	4 Credits
Pre-requisite: A basic knowledge of two-dimensional Cartesian plane.			
Course Objectives: This course is designed to introduce the geometry of two dimensions. The major focus of this course will be on geometric definition of two-dimensional shapes and a rigorous discussion on their properties and use.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Explain the different types of plane figures.
CO2	Visualize two-dimensional shapes geometrically.
CO3	Apply the knowledge of geometry of two dimensions in advance courses in mathematics.
CO4	Explain the Cartesian and Polar coordinate systems to study two dimensional shapes.
CO5	Study further the geometry of three dimensions.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	1	3	2	2	3
CO2	1	3	2	2	3
CO3	2	3	2	2	3
CO4	3	3	2	2	3
CO5	1	1	2	2	3

Course Title: Co-ordinate Geometry
Course Code: UC-BSHM-102-19

UNIT-I

Joint equation of pair of straight lines and angle between them, condition of parallelism and perpendicularity, joint equation of the angle bisectors, joint equation of lines joining origin to the intersection of a line and a curve.

UNIT-II

General equation of circle, circle through intersection of two lines, tangent and normal, Chord of contact, pole and polar, pair of tangents from a point, equation of chord in midpoint form, angle of intersection and orthogonality, power of a point w.r.t. circle, radical axis, co-axial family of circles, limiting points.

UNIT-III

Parabola, ellipse and hyperbola, tangent and normal, chord of contact, pole and polar of tangent from a point, equation of chord in terms of midpoint, diameter, conjugate diameters of ellipse and hyperbola, conjugate hyperbola, asymptotes of hyperbola, rectangular hyperbola.

UNIT-IV

Transformation of axes in two dimensions: shifting of origin, rotation of axes, the second degree equation $S = ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$, its invariants *t*, Δ and *O*. Reduction of the second degree equation into standard form. Identification of curves represented by *S=0* (including pair of lines).Polar equations of straight lines, circles and conics. Polar equation of chords, tangent and normal.

TEXT BOOKS

1. P. K. Jain, Khalid Ahmed, A Text book of Analytical Geometry of Two Dimensions, Wiley Eastern Ltd, 1999.

RECOMMENDED BOOKS:

2. S. L. Loney, The Elements of Coordinate Geometry, Macmillian & Comp., London, 2007

UC-BSHM-103-19	Programming Lab-I	L-0, T-0, P-2	2 Credits
Pre-requisite: Knowledge of basic concepts in Mathematics, such as, graphs, functions, conics, matrices etc.			
Course Objectives: This course is designed to introduce the basic knowledge of computer programming t simple algebraic operations on matrices and to visualize the geometry of curves and conics. two dimensions. The major focus of this course will be on geometric definition of two-dimensional shapes and a rigorous discussion on their properties and use.			
Course Outcomes: At the end of the course, the students will be able to			
CO1	Explain the basic concepts of programming.		
CO2	Apply the knowledge of programming in different Matrix Operations.		
CO3	Use programming in plotting and visualization of graphs of algebraic and transcendental functions.		
CO4	Obtain Surface of revolution of curves.		
CO5	Study further the tracing of conics.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	1	3	3	3	3
CO2	1	3	3	3	3
CO3	2	2	3	3	3
CO4	3	3	2	2	3
CO5	2	3	2	2	3

Course Title: Programming Lab-I

Course Code: UC-BSHM-103-19

The following programs with following methods are to be practiced to:

i) Introduce the programming through (FORTRAN, C etc.)

ii) Perform Matrix Operations, such as, Addition, Multiplication, inverse, Transpose etc.

iii) Plot the graphs of algebraic and transcendental functions (For example, e^{ax+b}, $\log(ax+b)$, $\frac{1}{ax+b,}$ with constants a, b, etc.)

iv) Obtain the surface of revolution of curves.

v) Trace of conics in Cartesian Coordinates /Polar Coordinates.

vi) Applications of derivative.

RECOMMENDED BOOKS:

1. V. Rajaraman, Computer Programming in Fortran 90 and 95, PHI Learning, 2004.
2. Ian Chivers and Jane Sleightholme, Introduction to Programming with Fortran, Springer, 4th edition, 2018.
3. Walter S. Brainerd, Guide to Fortran 2008 Programming, Springer Nature, 2015.

UC-BSHP-112-19	Electricity and Magnetism	L-3, T-1, P-0	4 Credits

Pre-requisite: Basic knowledge of Electricity and Magnetism at high school level.

Course Objectives: The objective of the course is to expose the students to the formal structure of electricity and magnetism so that they can use these as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and describe the different concepts of electromagnetism
CO2	To obtain the electric and magnetic fields for simple configurations under static conditions.
CO3	To analyse time varying electric and magnetic fields.
CO4	To understand Maxwell's equation in different forms and different media.
CO5	have a solid foundation in fundamentals required to solve problems and also to pursue higher studies.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	2	1	2	2	2	3	2	2
CO2	3	2	1	-	2	2	1	2	2	3	2	3
CO3	3	2	3	-	2	1	2	1	2	3	2	3
CO4	3	2	3	2	-	2	2	3	2	3	3	3
CO5	2	2	3	2	-	2	2	3	2	3	3	3

Course Title: Electricity and Magnetism

Course Code: UC-BSHP-112-19

UNIT-I

Review of Vector Analysis: Vector algebra, scalar and vector product; Concept of Fields; scalar and vector field; gradient, divergence and curl and their physical significance; Conservative field, Line, surface and volume integral of a vector field, Gauss-divergence theorem and Stoke's theorem.

UNIT II

Electrostatics: Electrostatic field; electric flux; Gauss's law in differential and integral form; Applications of Gauss law-Electric filed due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charge sheet; Electric potential as line integral of electric field, potential due to point charge and electric dipole; calculation of electric field from potential; Poisson's equation and Laplace's equation(Cartesian coordinate); Capacitance; capacitance of a spherical conductor and cylindrical capacitor, Energy per unit volume in electrostatic field, Dielectric medium, dielectric polarization and its types, Displacement vector, Boundary conditions.

UNIT-III

Magnetostatics: Magnetic flux; magnetic flux density; Faraday's law; magnetomotive force; Biot-Savart's law and its applications-straight conductor, circular coil, divergence and curl of magnetic field; Ampere's Circuital law in differential and integral form; Magnetic vector potential; ampere's force law; magnetic vector potential; Energy stored in a magnetic field, boundary conditions on magnetic fields.

UNIT-IV

Maxwell's Equations and Electromagnetic Waves: Equation of continuity for time varying fields; Inconsistency of ampere's law; concept of sinusoidal time variations (Phasor notation); Maxwell's equations in differential and integral form, physical significance; Maxwell equations in free space, static field and in Phasor notation; Difference between displacement current and conduction current; Wave equation in free space and in homogenous medium, Concept of Poynting vector; Poynting Theorem.

RECOMMENDED BOOKS:

1.David Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private Limited; 4thEdition.
2. E.C. Jordan and K.G. Balmain, Electromagnetic waves and radiating systems, Prentice Hall
3. Kraus John D, Electromagnetics, McGraw-Hill Publisher
4. W. Saslow, Electricity, magnetism and light, Academic Press
5.A Textbook of Electricity and Magnetism, S K Sharma, Shalini Sharma, S Dinesh & Co.
6. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.

UC-BSHP-113-19	**Physics Lab-I**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisite (If any): High-school education			
Course Objectives: The aim and objective of the lab course is to introduce the students to the formal structure of electromagnetism and phenomenon of wave optics so that they can use these as per their requirement.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Able to verify the theoretical concepts/laws learnt in theory courses.		
CO2	Trained in carrying out precise measurements and handling sensitive equipment.		
CO3	Understand the methods used for estimating and dealing with experimental uncertainties and systematic "errors".		
CO4	Learn to draw conclusions from data and develop skills in experimental design.		
CO5	Document a technical report which communicates scientific information in a clear and concise manner.		

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	1	-	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	1	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

Course Title: Physics Lab-I

Course Code: UC-BSHP-113-19

Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

List of experiments:

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the laser beam characteristics like; wave length, aperture, spot size, etc. using diffraction grating.
3. To study the diffraction using laser beam and thus to determine the grating element.
4. To study wavelength and laser interference using Michelson's Interferometer.
5. To find the refractive index of a material/glass using spectrometer.
6. To find the refractive index of a liquid using spectrometer.
7. To determine the resolving power of a prism.
8. To study the magnetic field of a circular coil carrying current using a Steward and Gees Tangent Galvanometer.
9. Determine the radius of circular coil using the Circular coil.
10. To study B-H curve using CRO.
11. To find out polarizability of a dielectric substance.
12. To find out the horizontal component of earth's magnetic field (B_h).

RECOMMENDED BOOKS:

1. A Text -book of Practical Physics, I. Prakash & Ramakrishna, 11thEdn, 2011, Kitab Mahal.
2. Engineering Practical Physics, S. Panigrahi& B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
4. Practical Physics, C L Arora. S. Chand & Company Ltd.
5. http://www.vlab.co.in

UGCA-1902	**Fundamentals of Computer and IT**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: NA			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understanding the concept of input and output devices of Computers		
CO2	Learn the functional units and classify types of computers, how they process information and how individual computers interact with other computing systems and devices.		
CO3	Understand an operating system and its working, and solve common problems related to operating systems		
CO4	Learn basic word processing, Spreadsheet and Presentation Graphics Software skills.		
CO5	Study to use the Internet safely, legally, and responsibly		

Course Title: Fundamentals of Computer and IT
Course Code: UGCA-1902

UNIT-I

Human Computer Interface: Concepts of Hardware and Software; Data and Information.
Functional Units of Computer System: CPU, registers, system bus, main memory unit, cache memory, Inside a computer, SMPS, Motherboard, Ports and Interfaces, expansion cards, ribbon cables, memory chips, processors.
Devices: Input and output devices (with connections and practical demo), keyboard, mouse, joystick, scanner, OCR, OMR, bar code reader, web camera, monitor, printer, plotter.
Data Representation: Bit, Byte, Binary, Decimal, Hexadecimal, and Octal Systems, Conversions and Binary Arithmetic (Addition/ Subtraction/ Multiplication) Applications of IT.

UNIT II

Concept of Computing, Types of Languages: Machine, assembly and High level Language; Operating system as user interface, utility programs.
Word processing: Editing features, formatting features, saving, printing, table handling, page settings, spell-checking, macros, mail-merge, equation editors.

UNIT-III

Spreadsheet: Workbook, worksheets, data types, operators, cell formats, freeze panes, editing features, formatting features, creating formulas, using formulas, cell references, replication, sorting, filtering, functions, Charts & Graphs.
Presentation Graphics Software: Templates, views, formatting slide, slides with graphs, animation, using special features, presenting slide shows.

UNIT-IV

Electronic Payment System: Secure Electronic Transaction, Types of Payment System: Digital Cash, Electronic Cheque, Smart Card, Credit/Debit Card E-Money, Bit Coins and Crypto currency, Electronic Fund Transfer (EFT),Unified Payment Interface(UPI), Immediate Payment System(IMPS), Digital Signature and Certification Authority. Introduction to Bluetooth, Cloud Computing, Big Data, Data Mining, Mobile Computing and Embedded Systems and Internet of Things (IoT).

RECOMMENDED BOOKS:

1. Introduction to Information Technology, ITL Education Solutions limited, Pearson Education

2. Computer Fundamentals, A. Goel, 2010, PearsonEducation.
3. Fundamentals of Computers, P. K.Sinha& P. Sinha, 2007, BPBPublishers.
4. IT Tools, R.K. Jain, Khanna PublishingHouse
5. "IntroductiontoInformationTechnology",SatishJain,AmbrishRai&Shashi Singh, Paperback Edition, BPB Publications,2014.
6. "Introduction to Computers", Peter Norton
7. Computers Today, D. H. Sanders, McGraw Hill.
8. "Computers", Larry long & Nancy long, Twelfth edition, PrenticeHall.
9. ProblemSolvingCasesinMicrosoftExcel,JosephBrady&EllenFMonk,Thomson Learning
10. www.sakshat.ac.in
11. https://swayam.gov.in/course/4067-computer-fundamentals

UGCA-1906	**Fundamentals of Computer and IT Laboratory**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisite (If any):NA			
CO1	Familiarizing with Open Office (Word processing, Spreadsheets and Presentation).		
CO2	To acquire knowledge on editor, spread sheet and presentation software.		
CO3	The students will be able to perform documentation and accounting operations.		
CO4	Students can learn how to perform presentation skills.		

Course Title: Fundamentals of Computer and IT Laboratory

Course Code: UGCA-1906

List of experiments:

- **Word Orientation:** The instructor needs to give an overview of word processor. Details of the four tasks and features that would be covered Using word – Accessing, overview of toolbars, saving files, Using help and resources, rulers, format painter.

  1) Using word to create Resume:
     Features to be covered:- Formatting Fonts in word, Drop Cap in word, Applying Text effects,Using Character Spacing, Borders and Colors, Inserting Header and Footer, Using Date and Time option in Word.
  2) Creating an Assignment
     Features to be covered:- Formatting Styles, inserting table, Bullets and Numbering, Changing Text Direction, Cell alignment, Footnote, Hyperlink, Symbols, Spell Check, Track Changes.
  3) Creating a Newsletter
     Features to be covered :- Table of Content, Newspaper columns, Images from files and clipart, Drawing toolbar and Word Art, Formatting Images, Textboxes and Paragraphs
  4) Creating a Feedback form
     Features to be covered :- Forms, Text Fields, Inserting objects, Mail Merge in Word.

- **Excel Orientation:** The instructor needs to tell the importance of Excel as a Spreadsheet tool, give the details of the four tasks and features that would be covered Excel - Accessing, overview of toolbars, saving excel files.

  1) Creating a Scheduler
     Features to be covered :- Gridlines, Format Cells, Summation, auto fill, Formatting Text
  2) Creating an Assignment
     Features to be covered:- Formatting Styles, inserting table, Bullets and Numbering, Changing Text Direction, Cell alignment, Footnote, Hyperlink, Symbols, Spell Check, Track Changes.
  3) Creating a Newsletter
     Features to be covered :- Table of Content, Newspaper columns, Images from files and clipart, Drawing toolbar and Word Art, Formatting Images, Textboxes and Paragraphs
  4) Creating a Feedback form
     Features to be covered :- Forms, Text Fields, Inserting objects, Mail Merge in Word.

- **Presentation Orientation:**
    1) Students will be working on basic power point utilities and tools which help them create basic power point presentation.
       Topic covered includes :- PPT Orientation, Slide Layouts, Inserting Text, Word Art, Formatting Text, Bullets and Numbering, Auto Shapes, Lines and Arrows
    2) This session helps students in making their presentations interactive.
       Topicscoveredincludes:Hyperlinks,Inserting–Images,ClipArt,Audio,Video, Objects, Tables and Charts
    3) Concentrating on the in and out of Microsoft power point. Helps them learn best practices in designing and preparing power point presentation. Topics covered includes: - Master Layouts (slide, template, and notes), Types of views (basic, presentation, slide slotter, notes etc), Inserting – Background, textures,DesignTemplates,Hiddenslides.Autocontentwizard,SlideTransition, Custom
    4) Animation, Auto Rehearsing
    5) Power point test would be conducted. Students will be given model power point presentation which needs to be replicated

- **Internet and its Applications:** The instructor needs to tell the how to configure Web Browser and to use search engines by defining search criteria using Search Engines
    1) To learn to setup an e-mail account and send and receive e-mails.
    2) Tolearntosubscribe/postonablogandtousetorrentsforaccelerateddownloads.
    3) Hands on experience in online banking and Making an online payment for any domestic bill.

RECOMMENDED BOOKS:

1. IT Tools, R.K. Jain, Khanna Publishing House.
2. Introduction to Information Technology, ITL Education Solutions limited, Pearson Education.
3. Introduction to information technology, Turban, Rainer and Potter, John Wiley and Sons.
4. ProblemSolvingCasesinMicrosoftExcel,JosephBrady&EllenFMonk,Thomson Learning.

Course Title: Inorganic Chemistry
Course Code: UC-BSHC-101-19

UNIT-I

Atomic Structure: Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: deBroglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ_2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s, p, d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

UNIT-II

Chemical Bonding-I: Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations, Packing of ions in crystals, Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy, Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids, Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

UNIT-III

Chemical Bonding-II: Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach), Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl,BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valenceshell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths, Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ioniccharacter from dipole moment and electronegativity difference.

UNIT-IV

Chemistry of s and p Block Elements: Inert pair effect, Relative stability of different oxidation states, diagonal relationship andanomalous behaviour of first member of each group, Allotropy and catenation, Complex formation tendency of s and p block elements, Hydrides and their classification ionic, covalent and interstitial, Basic beryllium acetate and nitrate. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses, Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine, Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

RECOMMENDED BOOKS:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
6. Shriver & Atkins, Inorganic Chemistry 5th Ed.

Course Title: Chemistry Lab-I

Course Code: UC-BSHC-102-19

List of Experiments:

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized KMnO4 solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilicacid) and external indicator.

Reference text:

1. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS.

BBA-GE101-18	**Managerial Economics I**	**L-5, T-1, P-0**	**6 Credits**
Pre-requisite: Understanding of basic knowledge of Managerial Economics			
Course Objectives: The primary objective of this course is to equip students with the necessary economic concepts, principles, theory and techniques and enhance their managerial decision making to address business problems in a globalized economic environment.			
Course Outcomes: After completion of the course, the students shall be able to:			
CO1	Understand the basic concepts of managerial economics and apply the economic way of thinking to individual decisions and business decisions.		
CO2	Measure price elasticity of demand, understand the determinants of elasticity and apply the concepts of price, cross and income elasticity of demand.		
CO3	Understand and estimate production function and Law of Diminishing Marginal Utility.		
CO4	Understand and explain four basic market models of perfect competition, monopoly, monopolistic competition, and oligopoly, and how price and quantity are determined in each model.		
CO5	Understand the different costs of production and how they affect short and long run decisions.		

Course Title: Managerial Economics I

Course Code: BBA-GE101-18

UNIT-I

Introduction to Managerial Economics: Managerial Economics: Meaning, Nature, Scope & Relationship with other disciplines, Role of managerial economics in decision Making, Opportunity Cost Principle, Production Possibility Curve, Incremental Concept, Scarcity Concept.
Demand and the Firm: Demand and its Determination: Demand function; Determinants of demand; Demand elasticity – Price, Income and cross elasticity. Use of elasticity for analyzing demand, Demand estimation, Demand forecasting, Demand forecasting of new product. **Indifference Curve Analysis:** Meaning, Assumptions, Properties, Consumer Equilibrium, Importance of Indifference Analysis, Limitations of Indifference Theory

UNIT-II

Production Function : Production function Meaning, Concept of productivity and technology, Short Run and long run production function Isoquants; Least cost combination of inputs, Producer's equilibrium; Return to scale; Estimation of production function.
Theory of Cost: Cost Concepts and Determinants of cost, short run and long run cost theory, **Modern** Theory of Cost, Relationship between cost and production function

UNIT-III

Revenue Curve: Concept of Revenue, Different Types of Revenues, concept and shapes of Total Revenue, Average revenue and marginal revenue, Relationship between Total Revenue, Average revenue and marginal revenue, Elasticity of Demand and Revenue relation
Market Structure: Market Structure: Meaning, Assumptions and Equilibrium of Perfect Competition, Monopoly, Monopolistic Competition, Oligopoly: Price and output determination under collusive oligopoly, Price and output determination under non-collusive oligopoly, Price leadership model.

UNIT-IV

Pricing: Pricing practices**;** Commodity Pricing: Economics of advertisement costs; Types of pricing practices
Factor Pricing: Demand and supply of factor of production; Collective bargaining, Concept of rent, profit, interest- Rate of return and interest rates; Real vs. Nominal interest rates. Basic capital theory–Interest rate and return on capital. Measurement of profit.
Note: Relevant Case Studies will be discussed in class.

RECOMMENDED BOOKS:

1. K.K .Dewett, *Modern Economic Theory,* S. Chand Publication
2. D.M.Mithani, *Managerial Economics Theory and Applications,* Himalaya Publication
3. Peterson and Lewis, *Managerial Economic,* Prentice Hall of India
4. Gupta, *Managerial Economics,* TataMcGraw Hills
5. Geetika, *Managerial Economics,* Tata McGraw Hills
6. D.N.Dwivedi, *Managerial Economic,* Vikas Publications
7. Froeb, *Managerial Economics*, Cengage Learning
8. Koutsoyiannis, A, Modern Micro Economics, Palgrave Macmillan Publishers, New Delhi.
9. Thomas Christopher R., and Maurice S. Charles, Managerial Economics – Concepts and Applications, 8th Edition,
10. Mehta, P. L, Managerial Economics – Analysis, Problems and Cases, Sultan Chand & Sons, Delhi.
11. Peterson and Lewis, Managerial Economics, 4th Edition, Prentice Hall of India Pvt. Ltd., New Delhi.
12. Shapiro, Macro Economics, Galgotia Publications.

UC-BSHL-105-19	**Communicative English -I**	**L-2, T-0, P-0**	**2 Credits**

Pre-requisite: Basic proficiency in Communication Skills

Course Objectives: The main objective of this course is:

- To help the students become proficient in LSRW-Listening, Speaking, Reading & Writing skills
- To help the students become the independent users of English language
- To develop in them vital communication skills, integral to their personal, social and professional interactions
- To teach them the appropriate language of professional communication
- To prepare them for job market

Course Outcomes: At the end of the course, the student will

CO1	acquire basic proficiency in reading &listening, writing and speaking skills
CO2	be able to understand spoken and written English language, particularly the language of their chosen technical field.
CO3	be able to converse fluently.
CO4	be able to produce on their own clear and coherent texts.
CO1	become proficient in professional communication, such as, interviews, group discussions, office environments, important reading skills as well as writing skills and thereby will have better job prospects.

Mapping of course outcomes with the program Specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	1	1	2	2	3	2	3	2	2
CO2	1	-	-	1	1	2	2	3	2	3	2	2
CO3	1	-	**-**	1	1	2	2	3	2	3	2	2
CO4	1	-	-	1	1	2	2	3	2	3	2	2
CO5	2	-	-	1	1	2	2	3	2	3	2	2

Course Title: Communicative English -I
Course Code: UC-BSHL-105-19

UNIT I(Literature)

(A) The Poetic Palette (Orient Black Swan, Second Edition, 2016)

The following poems from this anthology are prescribed:

1. Pippa's Song: Robert Browning
2. Apparently With No Surprise: Emily Dickinson
3. Fool and Flea: Jeet Thayil

(B) Prose Parables (Orient Black Swan, 2013)

The following stories from the above volume are prescribed:

a. The Kabuliwallah : Rabindranath Tagore
b. The Eyes Are Not Here: Ruskin Bond
c. Grief: Anton Chekov

UNIT-II

Vocabulary: Word Formation Processes; Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives; Synonyms, antonyms

Grammar: Subject-verb agreement; Noun-pronoun agreement; Misplaced modifiers; Articles

Determiners; Modals; Prepositions;

UNIT-III

Reading and Understanding: Close Reading; Comprehension;

UNIT-IV

Mechanics of Writing & Speaking Skills

Essay Writing (Descriptive/Narrative/Argumentative); Business letters; Précis Writing; Self

Introductions; Group Discussion

RECOMMENDED BOOKS:

1. John Eastwood, Oxford Practice Grammar, Oxford University Press, 2014
2. Michael Swan, Practical English Usage, OUP. 1995.
3. F.T. Wood, Remedial English Grammar, Macmillan. 2007.
4. William Zinsser, On Writing Well, Harper Resource Book 2001.
5. Sanjay Kumar and Pushp Lata, Oxford University Press. 2011.
6. Communication Skills, Oxford University Press. 2011.
7. Liz Hamp-Lyons and Ben Heasly, Study Writing, Cambridge University Press. 2006.

UC-BSHL-106A-19	**ਪੰਜਾਬੀਲਾਜ਼ਮੀ (Punjabi Compulsory)-I**	**L-2, T-0, P-0**	**2 Credits**

Pre-requisite: Understanding of senior secondary level Punjabi

Course Objectives: The objective of the course is:
1.To enhance the language ability of students.

2.To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.

Course Outcomes: At the end of the course, the student will be able to

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

Course Title: ਪੰਜਾਬੀਲਾਜ਼ਮੀ (Punjabi Compulsory)-I
Course Code: UC-BSHL-106A-19

UNIT-I

ਕਵਿਤਾਭਾਗ:

ਭਾਈਵੀਰਸਿੰਘ:

ਸਮਾਂ, ਚਸ਼ਮਾ

ਪ੍ਰੋ.ਪੂਰਨਸਿੰਘ :

ਪੰਜਾਬਨੂੰਕੂਕਾਂਮੈਂ, ਹੱਲਵਾਹੁਣਵਾਲੇ

ਪ੍ਰੋ.ਮੋਹਨਸਿੰਘ :

ਮਾਂ,ਕੋਈਆਇਆਸਾਡੇਵਿਹੜੇ,ਪਿਆਰਪੰਧ

ਅੰਮ੍ਰਿਤਾਪ੍ਰੀਤਮ:

ਆਖਾਂਵਾਰਿਸਸ਼ਾਹਨੂੰ,ਅੰਨਦਾਤਾ

UNIT-II

ਕਹਾਣੀਭਾਗ:ਸੰਤਸਿੰਘਸੇਖੋਂ :

ਪੇਮੀਦੇਨਿਆਣੇ

ਸੁਜਾਨਸਿੰਘ :

ਕੁਲਫੀ

ਕੁਲਵੰਤਸਿੰਘਵਿਰਕ :

ਤੂੜੀਦੀਪੰਡ

ਗੁਰਦਿਆਲਸਿੰਘ :

ਸਾਂਝ

UNIT-III

ਭਾਸ਼ਾਦਾਟਕਸਾਲੀਰੂਪ, ਭਾਸ਼ਾਤੇਉਪ-ਭਾਸ਼ਾਵਿਚਅੰਤਰ, ਪੰਜਾਬੀਦੀਆਂਉਪ-ਭਾਸ਼ਾਵਾਂ,ਪੰਜਾਬੀਭਾਸ਼ਾ:ਨਿਕਾਸਤੇਵਿਕਾਸ।

ਭਾਸ਼ਾਤੇਲਿਪੀ, ਗੁਰਮੁਖੀਲਿਪੀਦੀਆਂਵਿਸ਼ੇਸ਼ਤਾਵਾਂ, ਗੁਰਮੁਖੀਲਿਪੀ: ਨਿਕਾਸਤੇਵਿਕਾਸ।

UNIT-IV

ਸੰਖੇਪਰਚਨਾ (ਪ੍ਰੈਸੀ)

ਪੈਰ੍ਹਾਰਚਨਾ

ਸਰਲਅੰਗਰੇਜ਼ੀਪੈਰ੍ਹੇਦਾਪੰਜਾਬੀਅਨੁਵਾਦ

RECOMMENDED BOOKS:

1.ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ,2016.

UC-BSHL-106B-19	**ਮੁਢਲੀ ਪੰਜਾਬੀ (Mudhli Punjabi)-I**	**L-2, T-0, P-0**	**2 Credits**

Pre-requisite: Understanding of senior secondary level Punjabi

Course Objectives: The objective of the course is to:
1.enhance the language ability of students.

2.enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.

Course Outcomes: At the end of the course, the student will be able to

CO1	Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2	Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3	Understand the society through Punjabi language, literature and culture.
CO4	Learning science and in developing science literacy.
CO5	Improve the internal communication.

Course Title: (Mudhli Punjabi)-I
Course Code: UC-BSHL-106B-19

UNIT-I

ਪੈਂਤੀ ਅੱਖਰੀ (ਵਰਣਮਾਲਾ), ਅੱਖਰ ਕ੍ਰਮ
ਮਾਤਰਾਵਾਂ : ਮੁਢਲੀ ਜਾਣ-ਪਛਾਣ
ਲਗਾਖਰ :ਬਿੰਦੀ, ਟਿੱਪੀ, ਅੱਧਕ

UNIT-II

ਪੰਜਾਬੀ ਸ਼ਬਦ ਬਣਤਰ: ਮੁਢਲੀ ਜਾਣ-ਪਛਾਣ
ਮੂਲ ਸ਼ਬਦ , ਅਗੇਤਰ, ਪਿਛੇਤਰ
ਸਮਾਨਾਰਥਕ ਸ਼ਬਦ, ਵਿਰੋਧਾਰਥਕ ਸ਼ਬਦ
ਸ਼ੁੱਧ- ਅਸ਼ੁੱਧ: ਦਿੱਤੇ ਪੈਰ੍ਹੇ ਵਿੱਚੋਂ ਅਸ਼ੁੱਧ ਸ਼ਬਦ ਨੂੰ ਸ਼ੁੱਧ ਕਰਨਾ

UNIT-III

ਹਫਤੇ ਦੇ ਸੱਤ ਦਿਨਾਂ ਦੇ ਨਾਂ
ਬਾਰ੍ਹਾਂ ਮਹੀਨਿਆਂ ਦੇ ਨਾਂ
ਰੁੱਤਾਂ ਦੇ ਨਾਂ
ਇਕ ਸੌ ਤੱਕ ਗਿਣਤੀ ਸ਼ਬਦਾਂ ਵਿਚ

UNIT-IV

ਸਧਾਰਣ ਸ਼ਬਦਾਂ ਦਾ ਅੰਗਰੇਜ਼ੀ ਤੋਂ ਪੰਜਾਬੀ ਅਨੁਵਾਦ

ਸਧਾਰਣ ਸ਼ਬਦਾਂ ਦਾ ਪੰਜਾਬੀ ਤੋਂ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ

ਸੰਖੇਪਰਚਨਾ (ਪ੍ਰੈਸੀ)

ਪੈਰ੍ਹਾਰਚਨਾ

ਸਰਲਅੰਗਰੇਜ਼ੀਪੈਰ੍ਹੇਦਾਪੰਜਾਬੀਅਨੁਵਾਦ

Text and Reference Books

1.ਸੁਖਵਿੰਦਰ ਸਿੰਘ ਸੰਘਾ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਵਿਗਿਆਨ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਅਕਾਦਮੀ ਜਲੰਧਰ

SEMESTER-II

UC-BSHM-201-19	**Calculus-II**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Calculus-I

Course Objectives: The objectives of this course are to make the students understand the following:

1. The applications of differential calculus for tracing curves.
2. The concept of Integration and its definition as limit of sum and area under curve.
3. The relation between derivative and the integration of a function.
4. The concept of improper integrals.
5. Numerical techniques to find approximate integrals and applications of integration for length of arc, finding area and volume.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the techniques to sketch a curve using the concepts of differential calculus.
CO2	Visualize all concepts of differential calculus geometrically
CO3	Understand the concept of Integration.
CO4	Understand the fundamental relation between differential and Integral Calculus.
CO5	Apply the knowledge of integral calculus in finding length of arc, area under curves, volume and area of surface swept by curve during revolution.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3

Course Title: Calculus-II
Course Code: UC-BSHM-201-19

UNIT-I

Concavity and Convexity, points of inflexion, derivative of arc, radius of curvature, centre of curvature, chord of curvature, evolutes and involutes.

UNIT-II

Asymptotes, working rules of determining Asymptotes, Asymptotes in polar co-ordinates, Cusps, curve tracing (Cartesian and polar), introduction to envelopes.

UNIT-III

Anti derivative of function of real variable, Riemann sums, definite integrals and their properties, Indefinite integral and net change, the fundamental theorem of calculus, Improper Integrals: Infinite Integrals, Discontinuous intervals, comparison test for improper integrals (Scope: James Stewart; Chapter-), reduction formulae.

UNIT-IV

Approximate Integration: Midpoint rule, Trapezoidal rule, Simpson’s rule; applications of integrals to find length of arc and area between curves, finding volumes, area of surface of revolution.

TEXT BOOKS

1.James Stewart, Calculus, 5th Edition, Brooks/Cole(Thomson), 2003.
2.Maurice D Weir, Frank R. Giordano and Joel Hass, Thomas’ Calculus, 11th Edition, Pearson, 2008.
3.Shanti Narayan and P. K. Mittal: Differential Calculus, S. Chand

REFERENCE BOOKS

4.George B. Thomas and Ross. L. Finney: Calculus and Analytic Geometry, 9th Edition, Addison Wesley, 1998.

UC-BSHM-202-19	Solid Geometry	L-4, T-1, P-0	4 Credits

Pre-requisite: Two dimensional coordinate geometry.

Course Objectives: This course is designed to introduce the geometry of three dimensions. The major focus of this course will be on geometric interpretation of three-dimensional shapes and a rigorous discussion on their properties and use.

Course Outcomes: At the end of the course, the students will be able to

CO1	Use the idea of three-dimensional Cartesian coordinate system, shift of origin and rotation of axes.
CO2	Demonstrate knowledge and understanding of three dimensional shapes and their properties.
CO3	Visualize the three dimensional shapes, for example sphere, cylinder and cone etc.
CO4	Utilize the knowledge of geometry of three dimensions in other branches of mathematics, for example calculus and analysis.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	3
CO2	3	3	3	2	3
CO3	1	2	3	2	3
CO4	1	3	3	3	3

Course Title: Solid Geometry
Course Code: UC-BSHM-202-19

UNIT-I

Lines and planes in 3-dimension, change of axes, shift of origin, rotation of axes, sphere, and section of a sphere by a plane. Sphere through a given circle. Intersection of a line and sphere.

UNIT-II

Tangent and normal, tangent plane, angle of intersection of two spheres and condition of orthogonality, power of a point w.r.t. a sphere, Radical planes, radical axis, radical centre, coaxial family of spheres, limiting points.

UNIT-III

Cylinder, Cone, homogeneous equation of second degree in x, y, z, reciprocal cone, right circular and elliptic cones, surface of revolution, enveloping cones, right circular and elliptic cylinders. Hyperbolic cylinder.

UNIT-IV

Quadratic surfaces**:** Ellipsoid, hyperboloid, paraboloid, quadratic cone, tangent plane and normal.

REFERENCE BOOKS

1.P. K. Jain, Khalid Ahmad, Textbook of Analytical Geometry, 3rd Edition, New Age International Publishers, 2018.

2.Shanti Narayan, P.K. Mittal, Analytical Solid Geometry, 17th Revised Edition, S. Chand & Company, 2007.

UC-BSHM-203-19	**Computer Algebra System: MATLAB**	**L-0, T-0, P-2**	**2 Credits**

Pre-requisite: Knowledge of basic concepts in Mathematics such as graphs, functions, conics, matrices etc.

Course Objectives: This course is designed to introduce a Computer Algebra System: MATLAB which is currently used in scientific computations. The main focus will be on introduction to basic concepts of MATLAB using simple examples.

Course Outcomes: At the end of the course, the students will be able to

CO1	Explain the basic concepts of programming
CO2	Visualize functions in 2-D and 3-D
CO3	Make their own computer programs for solving problems of their interest
CO4	Use symbolic tools of MATLAB for solving problems arising in various fields of applications

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	2	3	3	3	3
CO2	1	3	3	3	3
CO3	2	2	3	3	3
CO4	3	3	2	2	3

Course Title: Computer Algebra System: MATLAB

Course Code: UC-BSHM-203-19

UNIT-I

The MATLAB environment, scalars, variables, arrays, mathematical operations with arrays, built-in and user defined functions, graphics: two-dimensional and three-dimensional, m-files: script and function files, functions: input; disp and fprintf, relational and logical operators.

UNIT-II

Symbolic math: symbolic objects and expressions; collect; expand; factor; simplify; solve; diff and int commands, Programming: if-end structure; if-else-end structure; loops: for-end and while-end.

Reference Books.

1.D. J. Highamand N. J. Higham, MATLAB Guide, 2nd Edition, Society for Industrial and Applied Mathematics (SIAM), 2005.

2.Amos Gilat, MATLAB: An Introduction with Applications, 5th Edition, John Wiley & Sons, 2014.

UC-BSHP-124-19	Waves and Vibrations	L-4, T-0, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: The objective of the course is to develop basic understanding of Interference, Diffraction and Polarization among students. The Students also learn about the LASER and its applications. Students will be equipped with knowledge to measure wavelength, refractive index and other related parameters, which will act as a strong background if he/she chooses to pursue sciences as a career.

Course Outcomes: At the end of the course, the student will be able to

CO1	Identify and illustrate physical concepts and terminology used in optics and other related wave phenomena
CO2	Analyze and understand the phenomenon of interference, and diffraction and their applications
CO3	Get thorough knowledge of the polarization of light and its changes upon reflection and transmission and will learn to analyze the polarization in optical systems.
CO4	Understand the simple harmonic motion and its application.
CO5	Describe the different types of lasers, its principle, properties of laser beam.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	-	1	2	1	2	3	2	2
CO2	2	2	1	2	1	1	1	1	1	3	1	1
CO3	3	2	2	2	1	1	2	1	1	3	1	1
CO4	2	2	2	2	1	1	2	1	1	3	1	1
CO5	2	2	2	2	1	1	2	1	1	3	1	1

Course Title: Waves and Vibrations
Course Code: UC-BSHP-124-19

UNIT I

Interference: Electromagnetic nature of light, Definition and properties of wave front, Huygens Principle, Temporal and Spatial Coherence, Division of amplitude and wave front, Young's double slit experiment, Lloyd's single mirror and Fresnel's Biprism, Interference in Thin Films, Newton's Rings and Michelson Interferometer. (11 Lectures)

UNIT-II

Diffraction and Polarization: Huygens Principle, Huygens-Fresnel Diffraction theory, Fraunhofer diffraction: Single slit. Circular aperture, Rayleigh criterion of resolution, Resolving Power of a telescope, Double slit, Multiple slits, Diffraction grating; Polarization, Plane polarized light, Representation of Unpolarized and Polarized light, Polarization by Reflection, Brewster's law, Malus Law, Polarization by Selective absorption by Crystals, Polarization by Scattering, Polarization by Double Refraction.
(11 Lectures)

UNIT-III

Simple Harmonic Motion: Simple harmonic motion, Energy of a SHO, Simple, Compound and Torsional pendulum, Electrical Oscillations, damped oscillations, damped harmonic oscillator – heavy, critical, and light damping, Damping coefficients, energy decay in a damped harmonic oscillator, quality factor, forced mechanical oscillators, resonance. (12 Lectures)

UNIT-IV

Laser and Application: Lasers, Spontaneous emission, Stimulated absorption, Stimulated emission, Einstein coefficients, Conditions for Laser actions, Population inversion, Different types of Laser, Pumping mechanism: Optical Pumping, Electric Discharge and Electrical pumping, Resonators, Two, Three, and Four level laser systems, Ruby laser, He-Ne gas Laser, Semiconductor laser, CO2 laser, applications of laser: Holography, Principle of Holography.
(11 Lectures)

Text and Reference Books:

1. Optics: A.K. Ghatak (Tata-McGraw Hill), 1992.
2. Fundamentals of Optics: F.A. Jenkins and H.E. White (McGraw Hill), 1981.
3. A Text Book of Optics: Subrahmaniyam N. &et al.(S. Chand Publishing) (2006).
4. O. Svelto, "Principles of Lasers", Springer Science & Business Media, 2010.

UC-BSHP-125-19	Physics Lab-II	L-0, T-0, P-4	2 Credits
Pre-requisites (if any): High-school education with Physics lab as one of the subject.			
Course Objectives: The aim and objective of the Physics Lab course is to introduce the students of B. Sc. (Hons.) Physics to the formal structure of wave and vibrations and mechanics so that they can use these as per their requirement.			
Course Outcomes: At the end of the course, the student will be			
CO1	Able to understand the theoretical concepts learned in the theory course.		
CO2	Trained in carrying out precise measurements and handling equipment.		
CO3	Learn to draw conclusions from data and develop skills in experimental design.		
CO4	Able to understand the principles of error analysis and develop skills in experimental design.		
CO5	Able to document a technical report which communicates scientific information in a clear and concise manner.		

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	1	-	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	1	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

List of experiments:

1. Measurement of volume using travelling microscope. Use of Plumb line and Spirit level.
2. To determine the frequency of an electrically maintained tuning fork in a) Transverse mode of vibration b) Longitudinal mode of vibration.
3. To find out the frequency of AC mains using sonometer.
4. To study the characteristic of Ge-Si junction diode.
5. To analyze the suitability of a given Zener diode as a power regulator.
6. To determine the horizontal and vertical distance between two points using a Sextant.
7. To determine the height of an inaccessible object using a Sextant.
8. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of **g** and (c) Modulus of rigidity.
9. To determine the time period of a simple pendulum for different length and acceleration due to gravity.
10. To study the variation of time period with distance between centre of suspension and centre of gravity for a compound pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.
11. To find the moment of inertia of an irregular body about an axis through its C.G with the torsional pendulum.
12. To determine the angular acceleration α, torque τ, and Moment of Inertia of flywheel.

Reference book and suggested readings:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11^{th}Edn, 2011, Kitab Mahal.
4. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
5. Practical Physics, G.L. Squires, 2015, 4^{th} Edition, Cambridge University Press.
6. Practical Physics, C L Arora, S. Chand & Company Ltd.

http://www.vlab.co.in

UGCA-1909	**Object Oriented Programming using C++**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: NA			
Course Outcomes: At the end of the course, the student will be able to			
CO1	To learn programming from real world examples.		
CO2	To understand Object oriented approach for finding Solutions to various problems with the help of C++ language.		
CO3	To create computer based solutions to various real-world problems using C++		
CO4	To learn various concepts of object oriented approach towards problem solving		

Course Title: Object Oriented Programming using C++
Course Code: UGCA-1909

UNIT-I

Principles of object oriented programming
Introduction to OOP and its basic features, Basic components of a C++, Program and program structure, Compiling and Executing C++ Program. Difference between Procedure Oriented Language(C) and Object Oriented Language. (12)

UNIT-II

Classes & Objects and Concept of Constructors
Defining classes, Defining member functions, Declaration of objects to class, Access to member variables from objects, Different forms of member functions, Access specifiers (Private, public, protected), Array of objects. Introduction to constructors, Parameterized constructors, Copy Constructor, Multiple constructors in class, Dynamic initialization of objects, Destructors.

(10)

UNIT-III

Inheritance and Operator overloading
Introduction to Inheritance, Types of inheritance: - Single inheritance, Multiple inheritance, Multilevel inheritance, Hierarchical inheritance, Hybrid inheritance, Defining operator overloading, Overloading of Unary and Binary operators, Rules for overloading operators.

(10)

UNIT-IV

Polymorphism and File Handling
Early Binding, Late Binding, Virtual Functions, pure virtual functions, Abstract Classes. Opening and Closing File, Reading and Writing a file.

(10)

Text Books:
1. Object Oriented Programming with C++, E. Balagurusami, Fourth Edition, Tata Mc-Graw Hill.
2. Object Oriented Programming in Turbo C++, Robert Lafore, Fourth Edition Galgotia Publications.
3. The C++ Programming Language, Bjarna Stroustrup, Third Edition, Addison-Wesley Publishing Company.
4. Object Oriented Programming Using C++, Salaria, R. S, Fourth Edition, Khanna Book Publishing.

UGCA-1910	**Object Oriented Programming using C++**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisite (If any): NA			
CO1	To learn programming from real world examples.		
CO2	To understand Object oriented approach for finding Solutions to various problems with the help of C++ language.		
CO3	To create computer based solutions to various real-world problems using C++		
CO4	To learn various concepts of object oriented approach towards problem solving		

Course Title: Object Oriented Programming using C++ Laboratory

Course Code: UGCA-1910

Instructions: Develop all program in C++

Assignments:

1. Write a program to enter mark of 6 different subjects and find out the total mark (Using cin and cout statement)
2. Write a function using reference variables as arguments to swap the values of pair of integers.
3. Write a function to find largest of three numbers.
4. Write a program to find the factorial of a number.
5. Define a class to represent a bank account which includes the following members as Data members: a) Name of the depositor b) Account Number c) Withdrawal amount d) Balance amount in the account

Member Functions:

a) To assign initial values b)To deposit an amount c) To withdraw an amount after checking the balance d) To display name and balance.

6. Write the above program for handling n number of account holders using array of objects.
7. Write a C++ program to compute area of right angle triangle, equilateral triangle, isosceles triangle using function overloading concept.
8. Consider a publishing company that markets both book and audio cassette version to its works. Create a class Publication that stores the title (a string) and price (type float) of a publication. Derive the following two classes from the above Publication class: Book which adds a page count (int) and Tape which adds a playing time in minutes(float). Each class should have get_data() function to get its data from the user at the keyboard. Write the main() function to test the Book and Tape classes by creating instances of them asking the user to fill in data with get_data() and thenndisplaying it using put_data().
9. Consider an example of declaring the examination result. Design three classes student, exam and result. The student has data members such as rollno, name. Create the lass exam by inheriting the student class. The exam class adds data members representing the marks scored in 5 subjects. Derive the result from exam-class and it has own data members like total, avg.
10. Write a program for overloading of Unary ++ operator.
11. Write a program for overloading of Binary + operator.

12. Write a program of Virtual Functions.
13. Write a program of Abstract Classes.
14. Write a program to read and write from file.

Reference Books:

1. Object Oriented Programming with C++, E. Balagurusami, Fourth Edition, Tata Mc-Graw Hill.
2. Object Oriented Programming in Turbo C++, Robert Lafore, Fourth Edition Galgotia Publications.
3. The C++ Programming Language, Bjarna Stroustrup, Third Edition, Addison- Wesley Publishing Company.
4. Object Oriented Programming Using C++, Salaria, R. S, Fourth Edition, Khanna Book Publishing.

UC-BHCL-113-19	Introduction to Organic Chemistry	L-3, T-1, P-0	4 Credits

Pre-requisite: Knowledge of basic concepts in Mathematics, such as graphs, functions, conics, matrices etc.

Course Objectives:

1. To teach the basic principles, reaction mechanisms and stereochemistry of organic compounds.
2. To impart knowledge regarding physical properties and chemical reactions of alkanes, alkenes, dienes, alkynes, arenes, alkyl and aryl halides etc.
3. To predict and account for the most commonly encountered reaction mechanisms (substitution, addition and elimination) in organic chemistry.
4. To teach the basic principles, reaction mechanisms and stereochemistry of organic compounds.
5. To impart knowledge regarding physical properties and chemical reactions of alkanes, alkenes, dienes, alkynes, arenes, alkyl and aryl halides etc.
6. To predict and account for the most commonly encountered reaction mechanisms (substitution, addition and elimination) in organic chemistry

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the fundamental concepts of organic chemistry i.e structure, bonding and various effects in organic compounds.
CO2	To learn the stereochemistry viz. optical isomerism, stereoisomerism and conformational isomerism of organic compounds.
CO3	To study the various known reactive intermediate in organic synthesis
CO4	To learn the fundamental and advanced concepts of reaction mechanisms along with the study of reaction mechanisms in various types of substitution addition and elimination reactions.
CO5	To predict the relationships between organic chemical structures and their reactivity.

Mapping of course outcomes with the program outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	-	2	-	3	1	-
CO2	2	-	3	-	3	3	-
CO3	3	3	4	-	3	3	-
CO4	3	4	3	4	4	5	4
CO5	2	3	4	2	4	4	4

Course Title: Introduction to Organic Chemistry

Course Code: UC-BHCL-113-19

Unit-I

Basics of Organic Chemistry Organic Compounds:

Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyper conjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. (11)

Unit-II

Introduction to types of organic reactions: -

Introduction to the types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. Stereochemistry: Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

(12)

Unit-III

Chemistry of Aliphatic Hydrocarbons

A. **Carbon-Carbon sigma bonds Chemistry of alkanes**: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. **Carbon-Carbon π- bonds:** Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction.

(12)

Unit-IV

Aromatic Hydrocarbons Aromaticity:

Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

(10)

REFERENCE BOOKS:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)

3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994

5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

UC-BHCP-119-19	Introduction to Organic Chemistry Lab	L-0, T-0, P-4	2 Credits

Pre-requisite: Knowledge of basic concepts in Mathematics, such as, graphs, functions, conics, matrices etc.

Course Objectives:

The objective of this course is to provide practical knowledge and illustrative experiments regarding qualitative analysis, isolation, and purification of organic compounds

Course Outcomes: At the end of the course, the students will be able to

CO1	To check the purity of organic compounds by determining the melting or boiling points.
CO2	To develop preparative skills for purification of organic compounds by crystallization method.
CO3	To determine the element or functional groups present in organic compound by organic qualitative analysis.
CO4	To present their work with practical skills and the awareness of health and safety procedures.
CO5	To apply related experiments for their research work.

Mapping of course outcomes with the program Specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	-	2	-	3	1	-
CO2	2	-	3	-	3	3	-
CO3	3	3	4	-	3	3	-
CO4	3	4	3	4	4	5	4
CO5	2	3	4	2	4	4	4

Course Title: Introduction to Organic Chemistry Lab
Course Code: UC-BHCP-119-19

Unit-I

Determination of melting point

Napthalene 80-82^o, Benzoic acid 121.5-122^o, Urea 132.5-133^o, Succinic acid 184.5-185^o, Cinnamic acid 132.5-133^o, Salicylic acid 157.5-158^o, Acetanilide 113.5-114^o, m-Dinitrobenzene 90^o, p-Dichlorobenzene 52^o, Aspirin 135^o

Determination of boiling point

Ethanol 78^o, Cyclohexane 81.4^o, Toluene 110.6^o, Benzene 80^o

Unit-II

Distillation

Simple distillation of ethanol-water mixture using water condenser
Distillation of nitrobenzene and aniline using air condenser

Crystallization

Concept of induction of crystallization
Phthalic acid from hot water (using fluted filter paper and stemless funnel)
Acetanilide from boiling water
Napthalene from ethanol
Benzoic acid from water

Unit-III

Qualitative Analysis

Elemental analysis

nitrogen, sulphur, chlorine, bromine, iodine

Functional groups

-phenols, carboxylic acids

Unit-IV

-carbonyl compounds - ketones, aldehydes
-carbohydrates
-aromatic amines
-amides, ureas and anilides
-aromatic hydrocarbons and their halo- derivatives

Reference Books

1.Brian S. Furniss, Antony J. Hannaford, Peter W.G. Smith and Austin R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Longman, London.

2. F.G. Mann and B. C. Saunders, Practical Organic Chemistry, Springer

3. J.T. Sharp, Practical Organic Chemistry: A student handbook of techniques.

4. Philippa B. Cranwell, Laurence M. Harwood and Cristopher J. Moody , Experimental Organic Chemistry, 3rd Edition, Wiley.

BBA-GE 201-18	**Managerial Economics II**	**L-5, T-1, P-0**	**6 Credits**
Pre-requisite: Understanding of basic knowledge of Managerial Economics			
Course Objectives: This course aims to acquaint students with economy as a whole including measurement of national income, inflation and unemployment, which an objective to inculcate understanding of macroeconomic environment of an economy for better decision making.			
Course Outcomes: After completion of the course, the students shall be able to:			

CO1	Explain the concept of national income and its measurement using different approaches.
CO2	Describe the underlying theories of demand and supply of money in an economy.
CO3	Make use of employment and national income statistics students will be able to describe and analyze the economy in quantitative terms.
CO4	Interpret macroeconomic issues like money, inflation and unemployment.
CO5	Identify the phases of the business cycle and the problems caused by cyclical fluctuations in the market economy

Mapping of course outcomes with the program o Specific utcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	2	3	2	2	-
CO2	3	2	2	3	2	3	
CO3	2	3	3	2	2	3	3
CO4	2	2	3	3	3	2	3
CO5	2	1	1	3	1	1	3

Course Title: Managerial Economics II

Course Code: BBAGE 201-18

UNIT-I

National Income: Measuring National Income. Problems in the measurement of National Income. Theories of Money: Nature and functions of money – Types of money: Near money, inside money and outside money. Theories of demand for money – defining demand for money – Classical theories of demand for money – Friedman's re-statement of Quantity Theory of Money; Liquidity preference theory and Keynesian Liquidity Trap. Theories of Supply of money; Defining supply of money; Measuring supply of money.

UNIT-II

Theories of Inflation and Unemployment: Meaning, Types and Theories of Inflation. - Cost of inflation and sacrifice ratio. - Measurement of Inflation in India - Policies to control inflation Meaning and types of unemployment. - Cost of unemployment and Oakun's Law Measurement of unemployment in India. - Concept of Stagflation - Concept of Philips Curve.

Unit-III

Business cycle: Meaning, types and phases. Monetary, Fiscal and Income policy – Meaning and instruments. Multiplier: Concept, Features and Leakages. Foreign trade multiplier.

Unit-IV

Macro-economic Framework in Indian Economy–Public Finance–Tax system in India– Financial Administration: Finance Commission.

RECOMMENDED BOOKS:

1. Ahuja, H.L.(2015) Macroeconomics-Theory and Policy. New Delhi: Sultan Chand.

2. Jhingan, M.L. (2016) Macro Economic Theory. Delhi: Vrinda Publications Pvt. Ltd

3. Dwivedi, D.N.(2017)Macroeconomics: Theory and Practice: Theory & Practice. New Delhi: McGraw Hill.

4. Jain, T.R., Khanna, O.P.(2014) Managerial Economics: V.K. Publications

5. Dewett, K.K., Navalur, M.H., (2006) Modern Economic Theory: New Delhi: Sultan Chand.

UC-BHHL-115-19	Communicative English -II	L-2, T-0, P-0	2 Credits

Pre-requisite: Basic proficiency in Communication Skills

Course Objectives: The main objective of this course is:

- To help the students become proficient in LSRW-Listening, Speaking, Reading & Writing skills
- To help the students become the independent users of English language
- To develop in them vital communication skills, integral to their personal, social and professional interactions
- To teach them the appropriate language of professional communication
- To prepare them for job market

Course Outcomes: At the end of the course, the student will

CO1	acquire basic proficiency in reading &listening, writing and speaking skills
CO2	be able to understand spoken and written English language, particularly the language of their chosen technical field.
CO3	be able to converse fluently.
CO4	be able to produce on their own clear and coherent texts.
CO5	become proficient in professional communication, such as, interviews, group discussions, office environments, important reading skills as well as writing skills and thereby will have better job prospects.

Mapping of course outcomes with the program Specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	2	3	2	2	2
CO2	3	2	2	3	2	3	3
CO3	2	3	3	2	2	3	3
CO4	2	2	3	3	3	2	3
CO5	2	1	1	3	1	1	3

Course Title: Communicative English-II
Course Code: BHHL115-19

UNIT-I
(Literature)

(C) ***The Poetic Palette* (Orient BlackSwan, Second Edition, 2016)**
The following poems from this anthology are prescribed:

4. The Soul's Prayer: Sarojini Naidu
5. I Sit and Look Out: Walt Whitman
6. Women's Rights: Annie Louise Walker

(D) ***Prose Parables* (Orient Black Swan, 2013)**
The following stories from the above volume are prescribed:

a. The Doctor's Word: R.K. Narayan
b. The Doll's House: Katherine Mansfield
c. Dusk: H.H. Munroe (Saki) (10)

UNIT-II

Vocabulary:
Standard abbreviations; One word substitution; Word Pairs (Homophones/Homonyms)
Grammar: Sentence Structures; Use of phrases and clauses in sentences; Transformation of Sentences; Importance of proper punctuation (6)

UNIT-III

Reading and Understanding:
Summary Paraphrasing; Analysis and Interpretation; Translation (from Hindi/Punjabi to English and vice-versa)
Close Reading; Comprehension;

(4)

UNIT-IV

Mechanics of Writing & Speaking Skills:
Report writing; Career Documents- Job applications, Resume/CV writing, Common Everyday Situations: Conversations & Dialogues, Formal Presentations

(10)

REFERENCE BOOKS

1.John Eastwood, Oxford Practice Grammar, Oxford University Press,2014
2.Michael Swan, Practical English Usage, OUP. 1995.
3. **F.T.Wood,** Remedial English Grammar,Macmillan,2007.
4. William Zinsser, On Writing, Well Harper Resource Book, 2001.
5. Sanjay Kumar and Pushp Lata, Communication Skills, Oxford University Press,2011.'
6.Liz Hamp-Lyons and Ben Heasly, Study Writing, Cambridge University Press. 2006.

UC-BHHL-116A	**PUNJABI COMPULSORY-II (ਪੰਜਾਬੀ ਲਾਜ਼ਮੀ-II)**	**L:2 , T:0, P:0**	**Credits:2**
Pre-requisite:	**ਪੰਜਾਬੀਲਾਜ਼ਮੀ (Punjabi Compulsory)-I**		
Course Objectives	1. To enhance the language ability of students. 2. To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.		

Course Outcomes: At the end of the course, the student will be able to

CO1. Translate and transfer/broadcast the western scientific knowledge in the local language.
CO2. Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
CO3. Understand the society through Punjabi language, literature and culture.
CO4. Learning science and in developing science literacy.
CO5. Improve the internal communication.

Mapping of course outcomes with the program Specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	3
CO5	2	3	2	2	2

Course Title: PUNJABI COMPULSORY-II (ਪੰਜਾਬੀ ਲਾਜ਼ਮੀ-II)
Course Code: BHHL116A-19

UNIT-I

ਡਾ.ਹਰਿਭਜਨ ਸਿੰਘ:
ਅਪ੍ਰਮਾਣਿਕ, ਤੇਰੇ ਹਜ਼ੂਰ ਮੇਰੀ ਹਾਜ਼ਰੀ ਦੀ ਦਾਸਤਾਨ
ਸ਼ਿਵ ਕੁਮਾਰ ਬਟਾਲਵੀ:
ਕੰਡਿਆਲੀ ਥੋਰ੍ਹ, ਧਰਮੀ ਬਾਬਲ ਪਾਪ ਕਮਾਇਆ, ਰੁੱਖ
ਪਾਸ਼:
ਇਨਕਾਰ,ਸਭ ਤੋਂ ਖਤਰਨਾਕ,ਦਹਿਕਦੇ ਅੰਗਿਆਰਾਂ 'ਤੇ
ਸੁਰਜੀਤ ਪਾਤਰ:
ਹੁਣ ਘਰਾਂ ਨੂੰ ਪਰਤਣਾ, ਕੁਝ ਕਿਹਾ ਤਾਂ..., ਪੁਲ

(8)

UNIT-II

ਕਹਾਣੀ ਭਾਗ:
ਸੰਤੋਖ ਸਿੰਘ ਧੀਰ:
ਕੋਈ ਇਕ ਸਵਾਰ
ਪ੍ਰੇਮ ਪ੍ਰਕਾਸ਼:
ਲੱਛਮੀ
ਮੋਹਨ ਭੰਡਾਰੀ :
ਘੋਟਣਾ
ਵਰਿਆਮ ਸਿੰਘ ਸੰਧੂ :
ਆਪਣਾ ਆਪਣਾ ਹਿੱਸਾ

(8)

UNIT-III

ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਦੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ
ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਉਪਰ ਪਏ ਪ੍ਰਭਾਵ

(6)

UNIT-IV

ਰਿਪੋਰਟਿੰਗ, ਸਮਾਚਾਰ ਲਿਖਣ ਦੀ ਵਿਧੀ ਤੇ ਤੱਤ
ਪੰਜਾਬੀ ਪੈਰ੍ਹੇ ਦਾ ਸਰਲ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ
ਦਫਤਰੀ ਚਿੱਠੀ ਪੱਤਰ

(8)

Reference Books

ਸੰਪ.ਡਾ.ਮਹਿਲ ਸਿੰਘ, ਸਾਹਿਤ ਦੇ ਰੰਗ, ਰਵੀ ਸਾਹਿਤ ਪ੍ਰਕਾਸ਼ਨ, ਅੰਮ੍ਰਿਤਸਰ, 2016.

UC-BHHL-116B	**MUDHLI PUNJABI-II (ਮੁਢਲੀ ਪੰਜਾਬੀ-II)**	**L:2 , T:0, P:0**	**Credits:2**
Pre-requisite:	ਮੁਢਲੀ ਪੰਜਾਬੀ **(Mudhli Punjabi)-I**		
Course Objectives	1. To enhance the language ability of students. 2. To enhance the ability of Learning science and developing science literacy through local language teaching with science subjects.		

Course Outcomes: At the end of the course, the student will be able to

- **CO1.** Translate and transfer/broadcast the western scientific knowledge in the local language.
- **CO2.** Translate and transfer the indigenous/traditional scientific knowledge available in local knowledge into English and other global languages.
- **CO3.** Understand the society through Punjabi language, literature and culture.
- **CO4.** Learning science and in developing science literacy.
- **CO5.** Improve the internal communication.

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	3
CO5	2	3	2	2	2

Course Title: MUDHLI PUNJABI-II (ਮੁਢਲੀ ਪੰਜਾਬੀ-II)
Course Code: BHHL116B-19

UNIT-I

ਸ਼ਬਦ ਸ਼੍ਰੇਣੀਆਂ : ਪਛਾਣ ਤੇ ਵਰਤੋਂ-
ਨਾਂਵ, ਪੜਨਾਂਵ
ਵਿਸ਼ੇਸ਼ਣ, ਕਿਰਿਆ
ਕਿਰਿਆ ਵਿਸ਼ੇਸ਼ਣ

(8)

UNIT-II

ਰੋਜ਼ਾਨਾ ਵਰਤੋਂ ਦੀ ਪੰਜਾਬੀ ਸ਼ਬਦਾਵਲੀ:
ਬਾਜ਼ਾਰ, ਵਪਾਰ, ਰਿਸ਼ਤੇ-ਨਾਤੇ ਤੇ ਕਿੱਤਿਆਂ ਸਬੰਧੀ।

(8)

UNIT-III

ਪੰਜਾਬੀ ਵਾਕ ਬਣਤਰ :
ਸਧਾਰਣ ਵਾਕ
ਸੰਯੁਕਤ ਵਾਕ
ਮਿਸ਼ਰਤ ਵਾਕ

(8)

UNIT-IV

ਸਧਾਰਣ ਵਾਕਾਂ ਦਾ ਅੰਗਰੇਜ਼ੀ ਤੋਂ ਪੰਜਾਬੀ ਅਨੁਵਾਦ

ਸਧਾਰਣ ਵਾਕਾਂ ਦਾ ਪੰਜਾਬੀ ਤੋਂ ਅੰਗਰੇਜ਼ੀ ਅਨੁਵਾਦ

(8)

Reference Books

1.ਸੁਖਵਿੰਦਰ ਸਿੰਘ ਸੰਘਾ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਵਿਗਿਆਨ, ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਅਕਾਦਮੀ ਜਲੰਧਰ

SEMESTER-III

UC-BSHM-301-19	Calculus-III	L-4, T-1, P-0	4 Credits

Pre-requisite: - Calculus of one variable

Course Objectives: The objectives of the course are to introduce the functions of several variable, the continuity, derivatives and integrals of the functions of several variables and their geometrical interpretations. One of the objectives is to introduce the applicability of the calculus of several variables to the students.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the functions of several variables and their behavior.
CO2	Find the partial derivatives, understand its geometrical meaning and understand their relation with total derivative
CO3	Find the maxima and minima of function of several variables and their expansion.
CO4	Understand the integrals of the functions of several variables and their geometrical interpretation
CO5	Applications of the calculus of several variables in the real world.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	-	-	3
CO2	3	3	-	-	3
CO3	3	3	-	-	3
CO4	3	3	-	-	3
CO5	1	3	-	-	3

Course Title: Calculus-III

Course Code: UC-BSHM-301-19

UNIT-I

Real valued functions of several variables with emphasis on functions of two and three variables, Limits and continuity, Partial derivatives, Homogenous Functions, Euler's Theorem

UNIT-II

Total differentiation, Differentiation of composite functions, Implicit functions, Chain Rule, Jacobians, Directional Derivatives, Gradient Vectors, Tangent Planes.

UNIT-III

Saddle Points, Maxima and Minima of functions of two variables, Lagrange's multiplier method, Higher dimensional analogues of Lagrange's Mean value Theorem and Taylor's theorem for functions of two variables.

UNIT-IV

Double integration over rectangular and non-rectangular regions, change of order of integration, double integration in polar co-ordinates, triple integration over parallelepiped and other solid regions, Applications of double and triple integrals to area, volume, centre of gravity, moment of inertia etc.

RECOMMENDED BOOKS:

1. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 9th Edition, Addison Wesley, 1998. (Scope as in Ch.11-13)

2. Shanti Narayan and P.K. Mittal, Differential Calculus, S. Chand & Co.

3. Shanti Narayan and P.K. Mittal, Integral Calculus, S. Chand & Co.

4. T. M. Apostol, Mathematical Analysis, 2nd Edition, Narosa Publishing House, Reprint 2002.

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

UC-BSHM-302-19	Algebra-I	L-4, T-1, P-0	4 Credits
Pre-requisite: - Complex numbers, Sets, Relation and Functions			
Course Objectives: This course is designed to introduce the basic notions of algebra. The major focus of the course will be on: De Moivre's theorem & its applications, matrices and their use in system of equations; theoretical foundation of theory of equations and their solutions.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Use the De Moivre's theorem for solving problems concerning powers of complex numbers and complex roots of polynomials etc.
CO2	Use matrices in solving system of equations.
CO3	Demonstrate linear independence and dependence of a set of vectors.
CO4	Find inverse of a matrix using Gauss-Jordan method.
CO5	Demonstrate the nature of solutions of polynomial equations.
CO6	Use Cardano's method, Ferrari method and Descarte's method for finding solutions of equations.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	3	-	-	1
CO2	2	3	-	-	1
CO3	3	3	-	-	1
CO4	2	3	-	-	1
CO5	3	3	-	-	1
CO6	3	3	-	-	1

Course Title: Algebra-I
Course Code: UC-BSHM-302-19

UNIT-I

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications. Linear independence and dependence of row and column vectors, elementary operations on matrices, inverse of a matrix using Gauss-Jordan method, echelon form, row rank and column rank of a matrix and their equivalence,

UNIT-II

System of linear equations (homogeneous and non-homogeneous), conditions for consistency, Polynomials, zeros of a polynomial, division algorithm, greatest common divisor, repeated roots, equal roots, fundamental theorem of algebra.

UNIT-III

Relationship between roots and the coefficients, Fundamental theorem of symmetric polynomials (without proof). Evaluation of symmetric functions of roots, Rational roots of polynomials with integral coefficients. Descartes' rule of sign.

UNIT-IV

Strum's theorem (statement only), Solution of cubic equation using Cardano's method, and biquadratic equation by Descartes method and Ferrari's method.

RECOMMENDED BOOKS

1. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Springer Nature, 2016

2.Shanti Narayan and P.K. Mittal, A Textbook of Matrices, S. Chand & Company, 2010.

3.S. Lipschutz and M. L. Lipson, Schaum's Outline of Linear Algebra, McGraw Hill Education, 3rd Edition, 2017.

4.A Kurosh, Higher Algebra, Moscow Mir Publisher, 1972.

5.H. W. Turnbull, Theory of Equations, Palala Press, 2018.

6.W. S. Burnside and A. W. Panton, The Theory of Equations, Vol-1, Dublin University Press, 1954.

7. Chandrika Prasad, Text Book on Algebra and Theory of Equations, Pothishala Pvt. Ltd., 2017.

UC-BSHM-303-19	**Real Analysis-I**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Students must have the knowledge of number system, limit.			
Course Objectives: The objective of the course on **Real Analysis-I** is to equip the B.Sc. (Hons) students with the real line, its properties. The various concepts of sequence, infinite series. Furthermore, students will be introduced to various tests to discuss the convergence, divergence of sequences and infinite series.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Learn the basic concepts of Real line and its properties.
CO2	Understand about bounded, unbounded and limit suprema and infima.
CO3	Use of Monotone Convergence theorem for the calculation of square roots.
CO4	Be acquainted with knowledge of convergent and divergent sequences.
CO5	Apply the learnt tests in establishing convergence, divergence, absolute convergence and conditional convergence of infinite series.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	1
CO5	2	2	2	2	1

Course Title: Real Analysis-I
Course Code: UC-BSHM-303-19

UNIT-I

Review of Algebraic properties, Rational and irrational numbers, Order properties of $\mathbb{R}$, Absolute value of a real number, Triangle inequality, Real line, δ-neighborhood of a point in $\mathbb{R}$, Idea of bounded above sets, bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of $\mathbb{R}$ (without proof).

UNIT-II

Sequence of real number, Limit of a sequence, Uniqueness of limits, Limit theorems, Bounded sequence, Convergent sequence, Squeeze theorem, Examples of divergent sequences, Monotone sequence, Monotone convergence theorem, Calculation of square roots, Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano-Weierstrass Theorem for Sequences, Cauchy sequence, Cauchy's Convergence Criterion.

UNIT-III

Infinite series, convergence and divergence of infinite series, The n^{th} term test, Harmonic series, Geometric series, Cauchy Criterion for convergence, Integral test, p-test, Comparison test, Limit Comparison test, Ratio test, Cauchy root test.

UNIT-IV

Absolute Convergence of infinite series, Comparison test, Root test, Ratio Test, Cauchy integral test, Kummer's test, Raabe's Test, Non-absolute convergence of infinite series, Alternating series, Leibniz test, Abel's Lemma, Abel's test, Dirichlet test.

RECOMMENDED BOOKS

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Edition. Singapore: John Wiley and Sons (Asia) Pvt. Ltd., 2002.
2. R.T. Smith, and R.B. Minton, R.B. Calculus, 4th Edition. McGraw-Hill Education, 2011.
3. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer International Publishing, 2018.
4. T.M. Apostol, Calculus, Volume I &II, 2nd edition. New Delhi: Wiley, 1969.
5. R.K. Jain and S.K. Iyengar, S.K. Advanced Engineering Mathematics, 5th Edition. New Delhi: Narosa Publication, 2011.
6. W.R. Wade, An Introduction to Analysis, 4th Edition. Person, 2010.

UC-BSHP-214-19	Elements of Modern Physics	L-3, T-1, P-0	4 Credits
Pre-requisite: Understanding of senior secondary level Physics and Mathematics			
Course Objectives: The objective of the course is to develop basic understanding concepts of modern physics, namely to special relativity and to the quantum nature of light and energy, emphasizing whenever possible, how classical concepts have shown up to be inadequate in explaining experiments, which will act as a strong background if he/she chooses to pursue science as a career.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	gained a deep understanding on the motivations that have led in the past century to the relativistic and quantum revolution in physics
CO2	demonstrate ability to apply wave-particle duality and uncertainty principle to solve physics problems.
CO3	demonstrate ability to solve quantum mechanical eigenvalue equations for various operators and obtain expectation values of the corresponding observables.
CO4	demonstrate ability to solve 1-D quantum problems including the quantum particle in a box, a well, the simple harmonic oscillator, and the transmission and reflection of waves.
CO5	solve problems involving the quantization of mass, charge, light, and energy including Avogadro's number, black-body radiation, photoelectric effect, and other related issues.

Mapping of course outcomes with the program Specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	-	1	2	1	2	3	2	2
CO2	2	2	1	2	1	1	1	2	1	3	2	1
CO3	3	2	2	2	1	1	2	2	1	3	2	1
CO4	2	2	2	2	1	1	2	1	1	3	1	2
CO5	2	2	2	2	1	1	2	1	1	3	1	1

Course Title: Elements of Modern Physics
Course Code: UC-BSHP-214-19

UNIT-I

Dual Nature of Waves and Matter: Black body ration, Planck's quantum, Planck's constant and light as a collection of photons; Photo Electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment, Problems with Rutherford model-instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

Lecture (10)

UNIT-II

Quantum Mechanics: Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; wave velocity and group velocity, Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wave function, probabilities and normalization; Probability and probability current densities in one dimension. One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example.

Lecture (10)

UNIT-III

Atomic structure: The nuclear atom, Electron orbits, Atomic spectra, The Bohr Model, Energy level and spectra, Correspondence principle, Nuclear motion, Atomic excitation, Many electron atoms, Exclusion Principle, electron spin, spin orbit coupling, X-ray spectra. Zeeman effect, Stern-Garlach experiment.

Lecture (10)

UNIT-IV

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Doppler effect, Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. Energy- Momentum Four Vector.

Lecture (10)

Recommended Books:

1. Arthur Beiser, , Concepts of Modern Physics, 2009, McGraw-Hill
2. J.R. Taylor, C.D. Zafirato and M.A. Dubson, Modern Physics, 2009, PHI Learning
3. Thomas A. Moore, Six Ideas that Shaped Physics: Particle Behave like Waves, 2003, McGraw Hill
4. E.H. Wichman, Quantum Physics, Berkeley Physics, Vol.4., 2008, Tata McGraw-Hill Co.
5. R.A. Serway, C.J. Moses, and C.A.Moyer, Modern Physics, 2005, Cengage Learning.

UC-BSHP-215-19	**Physics Lab-III**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisites (if any): High-school education with Physics lab as one of the subject.			
Course Objectives: The aim and objective of the Physics Lab course is to introduce the students of B. Sc. (Hons.) Physics to the formal structure of wave and vibrations and mechanics so that they can use these as per their requirement.			
Course Outcomes: At the end of the course, the student will be			
CO1	Able to understand the theoretical concepts learned in the theory course.		
CO2	Trained in carrying out precise measurements and handling equipment.		
CO3	Learn to draw conclusions from data and develop skills in experimental design.		
CO4	Able to understand the principles of error analysis and develop skills in experimental design.		
CO5	Able to document a technical report which communicates scientific information in a clear and concise manner.		

Mapping of course outcomes with the program Specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	2	1	2	3	2	3
CO2	3	3	3	3	2	2	1	1	1	3	2	3
CO3	3	3	2	-	2	1	2	1	1	3	2	3
CO4	3	2	2	2	-	2	2	1	2	3	2	3
CO5	2	2	2	2	-	2	2	1	1	3	2	3

Course Title: Physics Lab-III
Course Code: UC-BSHP-215-19

Note: Students are expected to perform about 8-10 experiments from the following list, selecting minimum of 6-7 from the Physical Lab and 2-3 from the Virtual lab.

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To show the tunneling effect in tunnel diode using I-V characteristics.
3. To determine work function of material of filament of directly heated vacuum diode
4. To determine value of Planck's constant using LEDs of at least 4 different colors.
5. Measurement of Planck's constant using black body radiation and photo-detector.
6. To determine work function of material of filament of directly heated vacuum diode.
7. To determine the ionization potential of mercury.
8. To determine the wavelength of H-alpha emission line of Hydrogen atom.
9. To determine the absorption lines in the rotational spectrum of Iodine vapour.
10. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.
11. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
12. To determine the value of e/m by magnetic focusing.
13. To experimentally demonstrate the concept of quantization of energy levels according to Bohr's model of atom using Franck-Hertz Apparatus.
14. To determine the wavelength of laser source using diffraction of single slit.
15. To determine the wavelength of laser source using diffraction of double slits.
16. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.

RECOMMENDED BOOKS:

1. http://vlab.amrita.edu/?sub=1&brch=195
2. Experimental Physics - M.A. Hippargi.
3. Experimental Physics – Gadad & Hiregoudar.
4. Practical Physics - C. L. Arora.
5. Advanced Practical Physics – Worsnop and Flint.
6. Practical Physics – Gupta & Kumar Vol I, Vol II

UGCA1914	**Programming in Python**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisites (if any): NA			
Course Outcomes: At the end of the course, the student will be			
CO1	Familiar with Python environment, data types, operators used in Python.		
CO2	Compare and contrast Python with other programming languages.		
CO3	Learn the use of control structures and numerous native data types with their methods.		
CO4	Design user defined functions, modules, and packages and exception handling methods.		
CO5	Create and handle files in Python and learn Object Oriented Programming Concepts.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	1	2	3	3	3
CO2	1	1	3	3	3
CO3	1	2	3	3	3
CO4	1	2	3	3	3
CO5	1	1	3	3	3

Course Title: Programming in Python

Course Code: UGCA-1914

UNIT-I

Introduction to Python Programming Language: Programming Language, History and Origin of Python Language, Features of Python, Limitations, Major Applications of Python, Getting, Installing Python, Setting up Path and Environment Variables, Running Python, First Python Program, Python Interactive Help Feature, Python differences from other languages.

Python Data Types & Input/Output: Keywords, Identifiers, Python Statement, Indentation, Documentation, Variables, Multiple Assignment, Understanding Data Type, Data Type Conversion, Python Input and Output Functions, Import command.

Operators and Expressions: Operators in Python, Expressions, Precedence, Associativity of Operators, Non Associative Operators. (12)

UNIT-II

Control Structures: Decision making statements, Python loops, Python control statements.

Python Native Data Types: Numbers, Lists, Tuples, Sets, Dictionary, Functions & Methods of Dictionary, Strings (in detail with their methods and operations). (10)

UNIT-III

Python Functions: Functions, Advantages of Functions, Built-in Functions, User defined functions, Anonymous functions, Pass by value Vs. Pass by Reference, Recursion, Scope and Lifetime of Variables.

Python Modules: Module definition, Need of modules, Creating a module, Importing module, Path Searching of a Module, Module Reloading, Standard Modules, Python Packages. (12)

UNIT-IV

Exception Handling: Exceptions, Built-in exceptions, Exception handling, User defined exceptions in Python.

File Management in Python: Operations on files (opening, modes, attributes, encoding, closing), read() & write() methods, tell() & seek() methods, renaming & deleting files in Python, directories in Python. (10)

Classes and Objects: The concept of OOPS in Python, Designing classes, Creating objects, Accessing attributes, Editing class attributes, Built-in class attributes, Garbage collection, Destroying objects.

Text Books:

1. Pooja Sharma, Programming in Python, BPB Publications, 2017.
2. R. Nageswara Rao, Core Python Programming, 2nd Edition, Dreamtech.

Reference Books:

1. Martin C. Brown ,Python, The complete Reference , Mc Graw Hill Education.
2. A. Martelli, A. Ravenscroft and S. Holden, Python in a Nutshell, OREILLY.

UGCA1917	**Programming in Python Laboratory**	**L-0, T-0, P-4**	**2 Credits**
Pre-requisites (if any): NA			
Additional material required in ESE: - Maintain practical note book as per the instructions given by the instructor.			
CO1	Solve simple to advanced problems using Python language.		
CO2	Develop logic of various programming problems using numerous data types and control structures of Python.		
CO3	Implement different data structures.		
CO4	Implement modules and functions.		
CO5	Design and implement the concept of object oriented programming structures.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	1	2	3	3	2
CO2	1	1	3	3	2
CO3	1	2	3	3	2
CO4	1	2	3	3	2
CO5	1	1	2	3	2

Course Title: Programming in Python Laboratory

Course Code: UGCA-1917

List of assignments:

1.	Compute sum, subtraction, multiplication, division and exponent of given variables input by the user.
2.	Compute area of following shapes: circle, rectangle, triangle, square, trapezoid and parallelogram.
3.	Compute volume of following 3D shapes: cube, cylinder, cone and sphere.
4.	Compute and print roots of quadratic equation $ax^2+bx+c=0$, where the values of a, b, and c are input by the user.
5.	Print numbers up to N which are not divisible by 3, 6, 9,, e.g., 1, 2, 4, 5, 7,….
6.	Write a program to determine whether a triangle is isosceles or not?
7.	Print multiplication table of a number input by the user.
8.	Compute sum of natural numbers from one to n number.
9.	Print Fibonacci series up to n numbers e.g. 0 1 1 2 3 5 8 13…..n
10.	Compute factorial of a given number.
11.	Count occurrence of a digit 5 in a given integer number input by the user.
12.	Print Geometric and Harmonic means of a series input by the user.
13.	Evaluate the following expressions: a. $x-x^2/2!+x^3/3!- x^4/4!+\ldots x^n/n!$ b. $x-x^3/3!+x^5/5!- x^7/7!+\ldots x^n/n!$
14.	Print all possible combinations of 4, 5, and 6.
15.	Determine prime numbers within a specific range.
16.	Count number of persons of age above 60 and below 90.
17.	Compute transpose of a matrix.
18.	Perform following operations on two matrices. 1) Addition 2) Subtraction 3) Multiplication
19.	Count occurrence of vowels.
20.	Count total number of vowels in a word.
21.	Determine whether a string is palindrome or not.
22.	Perform following operations on a list of numbers: 1) Insert an element 2) delete an element 3) sort the list 4) delete entire list
23.	Display word after Sorting in alphabetical order.
24.	Perform sequential search on a list of given numbers.
25.	Perform sequential search on ordered list of given numbers.
26.	Maintain practical note book as per their serial numbers in library using Python dictionary.
27.	Perform following operations on dictionary

	1) Insert 2) delete 3) change
28.	Check whether a number is in a given range using functions.
29.	Write a Python function that accepts a string and calculates number of upper case letters and lower case letters available in that string.
30.	To find the Max of three numbers using functions.
31.	Multiply all the numbers in a list using functions.
32.	Solve the Fibonacci sequence using recursion.
33.	Get the factorial of a non-negative integer using recursion.
34.	Write a program to create a module of factorial in Python.
35.	Design a Python class named *Rectangle*, constructed by a length & width, also design a method which will compute the area of a rectangle.
36.	Design a Python class named *Circle* constructed by a radius and two methods which will compute the area and the perimeter of a circle.
37.	Design a Python class to reverse a string 'word by word'.
38.	Write a Python program to read an entire *text file*.
39.	Design a Python program to read first n lines of a *text file*.
40.	Construct a Python program to write and append text to a file and display the text.

Text Books:

1.Pooja Sharma, Programming in Python, BPB Publications, 2017.
2.R. Nageswara Rao, Core Python Programming, 2nd Edition, Dreamtech.

Reference Books:

3. Martin C. Brown ,Python, The complete Reference , Mc Graw Hill Education.
4. A. Martelli, A. Ravenscroft, S. Holden, Python in a Nutshell, OREILLY.

UC-BHCL-204-19	**PHYSICAL CHEMISTRY**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: This course will equip students with the necessary knowledge concerning the fundamentals in the basic areas of physical chemistry viz. different states of matter, solutions and ionic equilibrium. The problem solving skills of students are expected to be enhanced through due weightage given to numerical problems in each unit.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the basic principles and theories pertaining to different states of matter
CO2	Solve various problems related to pH
CO3	Define the various laws pertaining to gaseous state and solutions.
CO4	Familiarise with the different colligative properties of solutions and the concept of abnormal molecular mass
CO5	Understand the basic structure and symmetry elements in solids

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	-	3	-	-	3
CO2	-	3	-	-	3
CO3	-	3	-	-	3
CO4	-	3	-	-	3
CO5	-	3	-	-	3

Course Tittle: Physical Chemistry
Course Code: UC-BHCP-204-19

UNIT-I

Gaseous State:

The kinetic molecular theory of gases, Postulates and derivation of kinetic gas equation and various gas laws, The ideal gas law: Applications, Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z* and its variation with pressure for different gases. Causes of deviation from ideal behavior. van der Waals equation of state, its derivation and application in explaining real gas behaviour. Numericals.

UNIT-II

Liquid and Solid State

Physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity and their determination, cleansing action of detergents.

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law

UNIT-III

Ionic equilibria:

Concept of Acids and Bases. Electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids.
Buffer solutions; buffer capacity, buffer range, buffer action
Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

UNIT-IV

Solutions and Colligative Properties:

Ways of expressing the concentration, lowering of vapour pressure, Raoult's Law. Colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

RECOMMENDED BOOKS:

1. P.W. Atkins and J. de Paula, Atkin's Physical Chemistry, Oxford University Press (2006).
2. S.H. Maron and C.F. Prutton, Principles of Physical Chemistry, 1st edition,Oxford and IBH (1958).
3. G.W. Castellan, Physical Chemistry, 4th edition, Narosa (2004)
4. I .N. Levine, Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010)
5. T. Engel and P. Reid, Physical Chemistry 3rd Ed., Prentice-Hall (2012)

UC-BHCL-208-19	Chemistry Lab-III	L-0, T-0, P-4	2 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

Course Objectives: To provide students practical knowledge and skills about various topics taught in theory class of physical chemistry, which in turn will enhance their problem solving and analytical skills.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the basic procedures for carrying out a physical chemistry practical like preparation and standardisation of solutions, handling the equipments and measuring with precision.
CO2	Correlate the theoretical and practical aspects and know about the limits of the experimental error.
CO3	Determine the various physical parameters for the various problems under study.
CO4	Verify various laws studied in the theory part.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	-	3	-	-	3
CO2	-	3	-	-	3
CO3	-	3	-	-	3
CO4	-	3	-	-	3
CO5	-	3	-	-	3

Subject Tittle: Chemistry Lab-III
Subject Code: UC-BHCP-208-19

UNIT-I

Preparation and Standardisation of Solutions.

UNIT-II

Surface tension measurements.
a) Determine the surface tension by (i) drop number (ii) drop weight method.
b) Study the variation of surface tension of detergent solutions with concentration.

UNIT-III

Viscosity measurement using Ostwald's viscometer.
a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
b) Study the variation of viscosity of sucrose solution with the concentration of solute.

UNIT-IV

pH metry
a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b) Preparation of buffer solutions of different pH;
(i) Sodium acetate-acetic acid
(ii) Ammonium chloride-ammonium hydroxide
c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d) Determination of dissociation constant of a weak acid.

Recommended Books

1. J.B. Yadav , Practical Physical Chemistry, Krishna
2. Findlay, Practical Physical Chemistry, Longman, New York

BBA 301-18	**Organizational Behaviour**	**L-5, T-1, P-0**	**6 Credits**
Pre-requisite: Understanding of senior secondary level Physics and Mathematics			
Course Objective: This course emphasizes the importance of human capital in the organizations of today. It gives an insight to the students regarding individual and group behaviour in any organization**.**			
Course Outcomes: At the end of the course, the student will be able to			
CO1	To explain the basics of Orgnaizational behaviour and various challenges for OB		
CO2	To illustrate the foundations of Individual Behaviour and various factors influencing individual behaviour viz. learning, personality, perception, attitude and motivation.		
CO3	To examine the dynamics of group development and group properties.		
CO4	To understand various dimensions of organisational culture.		
CO5	To analyse the process of conflict management and approaches to stress management.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	-	3	-	-	3
CO2	-	3	-	-	3
CO3	-	3	-	-	3
CO4	-	3	-	-	3
CO5	-	3	-	-	3

Course Title: Organizational Behaviour
Course Code: BBA 301-18

UNIT-I

Introduction: Meaning of organizational behaviour and its relevance in today's business environment, contributing disciplines to Organization Behaviour, challenges and opportunities for OB.
Individual behaviour in organization: Foundations of individual behaviour, Factors influencing Individual Behaviour.
Learning: Meaning, characteristics and theories: Classical conditioning theory, operant conditioning theory, social learning theory, behaviour modification.

UNIT-II

Perception: Nature, importance, perceptual process, factors influencing perception, perceptual errors.
Attitude: Meaning, importance, components and types of work related attitude.
Personality: Meaning, determinants of personality, personality traits.
Motivation: Meaning, types of motivation, theories of work motivation given by Maslow, Herzberg, McGregor, Vroom and Porter – Lawler.

UNIT-III

Group behaviour in organization: Group dynamics, Types of groups, Group development, theories of group development, Group norms and roles, Group cohesiveness,
Work Teams: Meaning, characteristics, types of team, Creating effective team.
Leadership: nature, leadership styles, Leadership theories: trait theory and behavioural theories.

UNIT-IV

Conflict Management: Meaning, types and sources of conflict, Process of conflict management, approaches to conflict management.
Stress management: sources of stress, approaches for stress management.
Organizational culture: meaning, concept, types of culture, dimensions of organizational culture.

Recommended BOOKS:

1. Robbins, Organization Behaviour, Pearson Education Asia
2. Luthans, Organization Behaviour, Tata McGraw Hill
3. Newstrom, Organizational Behaviour: Human Behaviour at Work, Tata McGraw Hill
4. L.M. Prasad, Organisation Behaviour, Sultan Chand
5. Parikh, Gupta, Organisational Behaviour, Tata McGraw Hill
6. Aswathappa, Organization Behaviour, Himalaya.

SEMESTER-IV

UC-BSHM-401-19	**Vector Calculus**	**L-4, T-1, P-0**	**5 Credits**

Pre-requisite: Students must have the knowledge of Scalar, Vectors and vector algebra.

Course Objectives: The objective of the course on **Vector Calculus** is to equip the B.Sc. (Hons) students with the theoretical as well as physical interpretations of scalar vector quantities. Their applications in real life engineering problems. Furthermore, students will be introduced to more general concept, that is, Tensors.

Course Outcomes: At the end of the course, the student will be able to

CO1	Learn the basic concepts of Vector algebra, Dot product, Cross product.
CO2	Learn about operations on vectors, such as, vector triple product, scalar triple product.
CO3	Understand the Differentiation of Vector valued functions, Scalar valued functions, gradient, Divergence and curl.
CO4	Be acquainted with Line, Surface and Volume integrals of vector (or scalar) valued functions. And, Gauss, Divergence and Stokes theorem, Tensors.
CO5	Apply the learnt techniques in solving various problems related to vectors.

Mapping of course outcomes with the program outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	2	2	2	2	1
CO5	2	2	2	2	1

Course Title: Vector Calculus
Course Code: UC-BSHM-401-19

UNIT-I

Vector Algebra: Dot and Cross product of two vectors, Scalar and vector product of three vectors. Scalar fields and vector fields. [Ref 2: Chapter-1B]
Introduction to Suffix notation and summation convention, Kronecker delta.

UNIT-II

Vector Differentiation: Vector functions, Differentiation of a vector function, General rules for differentiation of vector function, Chain rule, Geometric interpretation of $\frac{d\vec{r}}{dt}$, Velocity and acceleration, Scalar and vector point function. [Ref 2: Chapter-1C]

UNIT-III

Gradient, divergence and Curl: Vector Differential operator, Gradient of a scalar function, Geometric interpretation of Gradient, Directional Derivative, Properties of Gradient, Divergence of a Vector point function, Physical interpretation of Divergence, Curl of Vector point function, Physical interpretation of curl, Properties of divergence and curl, Repeated operations by ∇, Conservative vector field and Scalar Potential. [Ref 2: Chapter-1C]

UNIT-IV

Vector Integral Calculus: Introduction to Integration of vector functions, Line integral, Surface integral, Volume integral.
Integral Theorems: Green's theorem in the plane, Stoke's Theorem, Gauss' theorem of Divergence and their applications. [Ref 2: Chapter-1D]

RECOMMENDED BOOKS:

1. M. Spiegel, S. Lipschutz and D. Spellman, Vector Analysis and An Introduction to Tensor Analysis, 2nd Edition. U.K.: Schaum's Outline Series, McGraw Hill, 1980.
2. H. Anton and C. Rorres, Elementary Linear Algebra, New Delhi: Wiley, 2012.
3. P. C. Mathews, Vector Analysis, 2nd Indian reprint. Springer undergraduate Mathematics Series, Springer-Verlag London, 2008.
4. H. Lass, Vector and Tensor Analysis. McGraw Hill, 2007.
5. S. Narayan, Tensor Analysis. New Delhi: S. Chand, 2010.

UC-BSHM-402-19	**Ordinary Differential Equations**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: Calculus			
The Objective of this course is to introduce ordinary differential equations and basic theory of existence and uniqueness of solutions. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations appearing in various fields of science and technology.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Understand the basic definitions to know about ordinary differential equations, its various types and their solutions
CO2	Visualize the geometrical meaning of first order differential equation.
CO3	Understand the fundamental concepts about existence and uniqueness of solution of initial value problem
CO4	Understand the applications of differential equations in different type of phenomenon.
CO5	Apply power series method to obtain series solutions of differential equations

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	2	3	-	-	3
CO2	2	3	-	-	3
CO3	2	3	-	-	3
CO4	2	3	-	-	3
CO5	2	3	-	-	3

Course Title: Ordinary Differential Equations
Course Code: UC-BSHM-402-19

UNIT-I

Basic definitions, Formulation of differential equations, order and degree of differential equation, primitives, initial value problem and solution of differential equations, First order differential equations: Linear, non-linear differential equations, Solution by variables separable, homogeneous, non-homogeneous exact equations, reducible in exact form and integrating factors, Solution of Leibnitz and Bernoulli's differential equation.

UNIT-II

Geometrical interpretation of first order differential equation, Successive approximation, Existence and uniqueness of solution of first order differential equations, Lipschitz condition, Picard's existence and uniqueness theorem.

UNIT-III

First order and higher degree equations solvable for x, y, p and Clairaut's form, Linear differential equations of first and higher order with constant coefficients, exponential decay model, lake pollution model (case study of Lake Burley Griffin), exponential growth of population (Scope as in Chapters 1, 3 of S. L. Ross).

UNIT-IV

Linear differential equations with variable coefficients, Cauchy's Euler equation and Legendre's equation, Linear independence, Linear dependence, Wronskian, Variation of parameters method.

RECOMMENDED BOOKS

1. S.L. Ross, Differential Equations, 3rd edition, John Wiley and Sons, 2004
2. W. E. Boyce and R. C. Diprima, 4th edition, Elementary differential equations and boundary value problems, John Wiley and Sons,1986.
3. M.D. Raisinghania, Ordinary and Partial Differential Equations, S Chand Publisher,15th edition, 2013
4. E. A. Coddington, An introduction to ordinary differential equation, Prentice- Hall of India.

UC-BSHM-403-19	**Linear Algebra**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: - Sets, Relations and Functions			
Course Objectives: This course is designed to introduce the basic concepts of linear algebra *viz*. vector spaces, linear transformation and eigenvalue problem etc. The main focus of the course will be on theoretical foundation of these concepts including explanation through examples.			
Course Outcomes: At the end of the course, the students will be able to			
CO1	Deal with the notions of vector spaces and linear transformations.		
CO2	Demonstrate matrix representation of linear transformation.		
CO3	Deal with the eigenvalue and eigenvector problem arising in different fields of applications, for instance, in solution of system of linear differential equations and stability of numerical methods etc.		
CO4	Diagonalize a given matrix using the eigenvalues and eigenvectors of the corresponding matrix.		
CO5	Demonstrate similarity of matrices and use of a method to check similarity of two matrices.		

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	3	3	**-**	**-**	1
CO2	3	3	**-**	**-**	1
CO3	2	3	**-**	**-**	1
CO4	2	3	**-**	**-**	1
CO5	2	3	**-**	**-**	1

Course Title: Linear Algebra
Course Code: UC-BSHM-403-19

UNIT-I

Vector spaces, subspaces, span of a set, intersection and union of subspaces, direct sum of subspaces, linear dependence and independence of vectors, basis and dimension of a vector space, finite dimensional vector spaces.

UNIT-II

Linear transformations, matrices as linear transformations, kernel and image of linear transformation, rank and nullity of a linear transformation, Rank-Nullity theorem, inverse of a linear transformation,

UNIT-III

Singular and non-singular linear transformations, isomorphism, algebra of linear maps, composition of linear maps, Matrix representation of a linear transformation, properties of matrix representation, change of basis.

UNIT-IV

Polynomials of matrices, characteristic polynomial, eigenvalues and eigenvectors, properties of eigenvalues and eigenvectors, Cayley-Hamilton theorem and its applications, similarity of matrices, diagonalization of a matrix, quadratic forms, minimal polynomial.

RECOMMENDED BOOKS

1. Serge Lang, Introduction to Linear Algebra, 2nd Edition, Springer, 1997.

2. D. C. Lay, S. R. Lay, J. J. McDonald, Linear Algebra and its Applications, 5th Edition, 2014.

3. V. Krishnamurthy, V. P. Mainra, J. L. Arora, Introduction to Linear Algebra, East-West Press, 1976.

UC-BSHM-404-19	**Probability and Statistics**	**L-4, T-1, P-0**	**4 Credits**
Pre-requisite: - Basic statistics, Permutation & combination and the basic knowledge of probability at 10+2 level.			
Course Objectives: The objective of the course is to prepare students for big data analysis by introducing basic concepts of statistics and probability theory along with their applications.			
Course Outcomes: At the end of the course, the students will be able to			

CO1	Understand the measures of central tendency, the concepts like skewness and standard deviation of the data.
CO2	Correlate bivariate and multivariate data.
CO3	Fit the curve by collecting random data and understand regression lines.
CO4	Understand the mathematical definition of probability, conditional probability and its applications.
CO5	Understand the theoretical concepts like random variable, probability distribution, generating functions and their usage.

Mapping of course outcomes with the program Specific outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	1	3	-	-	3
CO2	1	3	-	-	3
CO3	2	3	-	-	3
CO4	2	3	-	-	3
CO5	3	3	-	-	3

Subject Title: Probability and Statistics

Code: UC-BSHM-404-19

UNIT-I

Measure of central tendency, Measure of dispersion, Coefficient of variation, relation between measure of dispersion, Standard deviation of the combination of two groups, Moments, Skewness, Kurtosis. Correlation, Rank correlation.

UNIT-II

Curve fitting, graphical method, laws reducible to linear law, Principle of least squares, Method of least square, Fitting of $y=ax^n$, $y=ae^{bx}$, $xy^n=b$; method of group averages, fitting a parabola, method of moments, Regression, lines of regression.

UNIT-III

Definition of probability, probability and set notations, Addition law of probability, Independent events-Multiplication law of probability, Baye’s theorem

UNIT-IV

Random variable, discrete probability distribution, continuous probability distribution, expectation, variance, moments, moment generating function, probability generating function.

RECOMMENDED BOOKS:

1. S.C. Gupta and V.K. Kapoor, Mathematical Statistics.
2. Olive Jean Dunn, Virginia A. Clark, Basic Statistics, John Wiley & Sons, Inc., Publication.

EVS-101A	**Environmental Studies**	**L-2, T-0, P-0**	**2 Credits**
Pre-requisites (if any): NA			
Course Objectives: The aim and objective of this course is to teach the fundamental concepts of Environment as a whole along with Natural Resources, their types, and issues related with sustainable use as its components along with social issues related with environment.			
Course Outcomes: At the end of the course, the student will be			
CO1	Understand the fundamental concepts about Environment and its components.		
CO2	Know about various types of natural resources, their functions, uses, exploitation and the problems arise due to these along with suitable case studies.		
CO3	Gain knowledge about working of various ecosystems, their features and functions and energy flow through them.		
CO4	Know about biodiversity, its various forms, importance and important areas		

Mapping of course outcomes with the program outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	3	-	-	3
CO2	1	2	-	-	3
CO3	1	3	-	-	3
CO4	1	2	-	-	3

Course Tittle: Environmental Studies
Course Code: EVS-101A

UNIT-I

Multidisciplinary nature of environmental studies, Definition, scope and importance, Need for public awareness. (2)

UNIT-II

Natural Resources : Renewable and non-renewable resources : Natural resources and associated problems.
a) Forest resources : Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
b) Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
c) Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
d) Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
e) Energy resources : Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies.
f) Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification.
• Role of an individual in conservation of natural resources.
• Equitable use of resources for sustainable lifestyles. (10)

UNIT-III

Ecosystems
• Concept of an ecosystem.
• Structure and function of an ecosystem.
• Producers, consumers and decomposers.
• Energy flow in the ecosystem.
• Ecological succession.
• Food chains, food webs and ecological pyramids.
• Introduction, types, characteristic features, structure and function of the following ecosystem :-
a. Forest ecosystem
b. Grassland ecosystem
c. Desert ecosystem
d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) (8)

UNIT-IV

Biodiversity and its conservation

• Introduction – Definition : genetic, species and ecosystem diversity.
• Biogeographical classification of India
• Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values
• Biodiversity at global, National and local levels.
• India as a mega-diversity nation
• Hot-spots of biodiversity.
• Threats to biodiversity : habitat loss, poaching of wildlife, man-wildlife conflicts.
• Endangered and endemic species of India
• Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity (6)

RECOMMENDED BOOKS

1. K.C. Aggarwal, Environmental Biology, Nidi Publishers, 2001
2. E.P. Odum, Fundamentals of Ecology, WB Saunders, 1971
3. Erach Bharucha, The Biodiversity of India, Mapin Publishers, 2003
4. Benny Joseph, Environmental Studies, McGraw Hills, 2015.
5. R Rajagopalan, Environmental Studies, Oxford Higher Education, 2016.
6. S.P. Misra & S.N. Pandey, Essential Environmental Studies, Ane Books Pvt. Ltd. 2016

Semester Fifth **Contact Hour: 28**

S. No	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-501-19	Real Analysis-II	4	1	-	40	60	100	4
2.	UC-BSHM-502-19	Algebra-II	4	1	-	40	60	100	4
3.	UC-BSHM-503-19	Numerical Methods	4	1	-	40	60	100	4
4.	UC-BSHM-504-19	Partial Differential Equations	4	1	-	40	60	100	4
5.	UC-BSHM-505-19	Project Work	-	-	8	60	40	100	4

L: Lectures **T: Tutorials** **P: Practical**

Semester Sixth **Contact Hours: 25**

S. No	Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Cr
			L	T	P	Internal	External		
1.	UC-BSHM-601-19	Number Theory	4	1	-	40	60	100	4
2.	UC-BSHM-602-19	Complex Analysis	4	1	-	40	60	100	4
3.	UC-BSHM-603-19	Mechanics	4	1	-	40	60	100	4
4.	UC-BSHM-604-19	Discrete Mathematics	4	1	-	40	60	100	4
5.	UC-BSHM-605-19	Integral Equations and Integral Transforms	4	1	-	40	60	100	4

L: Lectures **T: Tutorials** **P: Practical**

UC-BSM-501-19	**Real Analysis-II: Metric Spaces and Reimann Integration**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Differential and Integral Calculus, Basic set theory

Course Objectives: The objectives of this course are to:

1. Develop understanding of abstract mathematical concepts.
2. Develop analytical and logical skills of students.
3. Introduce to students the basic theorems of real analysis
4. Prepare students for the study of advanced analysis.
5. Develop understanding of Reimann integrable functions and their properties.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the basic concepts of Real Analysis.
CO2	Visualize abstract mathematical concepts
CO3	Understand basic theorems related to real analysis.
CO4	Understand the logical concepts and apply the knowledge to derive the basic results.
CO5	Understand the behavior of Reimann integrable functions.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**5**	**-**	**-**	**-**	**4**
CO2	**5**	**-**	**-**	**-**	**-**
CO3	**5**	**-**	**-**	**-**	**-**
CO4	**5**	**3**	**-**	**-**	**5**
CO5	**-**	**5**	**-**	**-**	**4**

Course Title: Real Analysis-II

Course Code: UC-BSHM-501-18

UNIT-I

Metric spaces: open sets, closed sets, limit points, interior of a set, closed set, dense and nowhere dense sets, exterior, frontier and boundary points and their properties, balls and bounded sets, limits and continuity (Definition and basic examples only of all above concepts). Sequences in metric spaces, convergent and Cauchy sequences, Complete Metric Spaces (Scope as in ref. 6, Chapter 1, section-1.2, 1.3, 1.4 definition and examples with propositions 1.4.1, 1.4.3 and 1.4.7 / ref.5 section 8.1.10-8.1.18 and sec.8.2).

UNIT-II

Compact sets in a metric space, Heine Borel theorem, sequential compactness, Bolzano Weierstrass property, finite intersection property, continuity and compactness, separable sets, (Scope as in ref. 6, Chapter 5, Theorems 5.1.1-5.1.10, 5.1.14-5.1.15 only). Connectedness, connected subsets of reals, continuity and connectedness. (Basic definitions and fundamental theorems only: Scope as in ref. 6, Chapter 4, Theorems 4.1.3 to 4.1.11 only)

UNIT-III

Riemann Integration, Upper and Lower Darboux Sums, Riemann Sums and definition of Riemann integral through Riemann sums, Cauchy Criterions for integrability, Equivalence of two definitions. The Class of Riemann integrable functions, Properties of the Riemann integral, Fundamental theorems of Calculus. Scope as in Ref 2. Chapter 6 (Art. 32.1 to 32.9, 33.1, 33.2, 33.3, 33.4 to 33.8, 33.9, 34.1, 34.3)

UNIT-IV

Improper Integrals, Tests for Convergence of Improper Integrals, Beta and Gamma functions.

Scope as in Ref. 3 Chapter 11 and ref. 2, 8.17 to 8.20.

Text Books

1. T. M. Apostol, Mathematical Analysis, 2nd Edition, Narosa Publishing House, Reprint 2002.
2. K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
3. S. C. Malik and Savita Arora, Mathematical Analysis, 3rd Edition, New Age International Publishers, 2008.
4. Shanti Narayan, A Course of Mathematical Analysis, S. Chand and Company Ltd.1984.
5. William F.Trench, Introduction to real Analysis, Trinity University, San Antonio, Texas, USA, (Open Book Initiative of American Institute of Mathematics)

6. Satish Shirali, Harkishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.

Reference Books

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
2. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
3. M. H. Protter and C. B. Morrey, A First Course in Real Analysis, 2nd Edition, Springer Verlag, Indian Reprint, 2004.
4. W. Rudin. Principles of Mathematical Analysis, 3rd edition. McGraw Hill, 1976.
5. N. L. Carothers, Real Analysis, Cambridge University Press 2000.

UC-BSM-502-19	Algbera-II	L-4, T-1, P-0	4 Credits

Pre-requisite: Sets, Relations and Functions

Course Objectives: The objectives of this course are to:

1. Develop understanding of axiomatic algebraic structures.
2. Develop analytical and logical skills of students.
3. Introduce basic algebraic structures: Groups and Rings.
4. Prepare students for the study of advanced abstract algebra.
5. Deal with axiomatic structures occurring in science and engineering.

Course Outcomes: At the end of the course, the students will be able to

CO1	Deal with different algebraic structures occurring in abstract algebra.
CO2	Analyze algebraic structure Group and its properties.
CO3	Analyze algebraic structure Ring and its properties.
CO4	Apply the knowledge of abstract mathematics in studying advanced pure mathematics.
CO5	Apply the methods of proofs in proving theoretical results in other branches, for example, in science and engineering.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	**5**	**-**	**-**	**-**	**5**
CO2	**5**	**-**	**-**	**-**	**5**
CO3	**5**	**-**	**-**	**-**	**5**
CO4	**5**	**-**	**-**	**-**	**5**
CO5	**5**	**-**	**-**	**-**	**5**

Course Title: Algebra-II

Course Code: UC-BSHM-502-18

UNIT-I

Binary operations, symmetries of a square, Groups, semi groups, quaternion groups, groups of integers modulo n, symmetric groups, cyclic notation for permutations, even and odd permutations, properties of permutations, elementary properties of groups.

UNIT-II

Subgroups and examples of subgroups, center of a group, centralizer, normalizer, cosets, Lagrange's theorem on finite groups, index of a subgroup, product of two subgroups, Cyclic groups and their properties.

UNIT-III

Normal subgroups, simple subgroup, quotient group, Group homomorphisms, properties of homomorphism, properties of isomorphism, First, second and third isomorphism theorems, Dihedral group, permutation groups, Cayley's theorem.

UNIT-IV

Definitions and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring, Ideals, sum and product of ideals.

Textbooks

1. V. K. Khanna, S. K. Bhambri, A Course in Abstract Algebra, 4th Ed., Vikas Publishing House, 2013.
2. John B. Fraleigh, Neal E. Brand, A First Course in Abstract Algebra, 8th Ed., Pearson, 2021.

Reference Books

1. M. Artin, Algebra, 2nd Ed., Pearson, 2011.
2. Joseph A. Gallian, Contemporary Abstract Algebra, 8th Ed., Cengage, 2013.

UC-BSM-503-19	Numerical Methods	L-4, T-1, P-0	4 Credits

Pre-requisite: Differential and Integral Calculus

Course Objectives: The objectives of this course are to:

1. Introduce numerical methods for solving continuous problems which are difficult to deal with analytically.
2. Develop analytical and computational skills of students.
3. Introduce methods to deal with nonlinear equations, system of linear algebraic equations.
4. Introduce methods for constructing interpolating polynomials.
5. Introduce methods to deal with numerical differentiation, numerical integration and ordinary differential equations.
6. Develop understating of computational mathematics and also to demonstrate its importance in science and engineering.

Course Outcomes: At the end of the course, the students will be able to

CO1	Find approximate numerical solutions of nonlinear equations and system of linear algebraic equations.
CO2	Develop and use interpolating polynomials when explicit form of the function of interest is not known or complicated to deal with.
CO3	Deal with differentiation and definite integral problems approximately when it is difficult to get exact evaluation of these.
CO4	Apply the numerical methods for solving ordinary differential equations when it is difficult to deal with them analytically.
CO5	Apply the understanding of computational techniques in dealing with real world problems occurring in science and engineering.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**3**	**4**	**-**	**-**	**5**
CO2	**3**	**5**	**-**	**-**	**5**
CO3	**3**	**4**	**-**	**-**	**5**
CO4	**3**	**4**	**-**	**-**	**5**
CO5	**3**	**3**	**-**	**-**	**5**

Course Title: Numerical Methods

Course Code: UC-BSHM-503-18

UNIT-I

Computer representation of numbers, scientific notation, accuracy of numbers, errors and its different types, estimation of errors, propagation of errors, the concepts of stability and condition number. Polynomial and transcendental equations: Bisection method, Newton-Raphson's method, Secant method, Regula-Falsi method, General iteration method, Rate of convergence.

UNIT-II

System of linear algebraic equations, Gaussian elimination method, Gauss-Jordan method. Iterative methods: Gauss Jacobi method, Gauss-Seidel method and their convergence analysis. Interpolation, Lagrange interpolation, Newton's divided difference interpolation, Newton's forward and backward difference interpolation formulas.

UNIT-III

Numerical differentiation: methods based on finite differences. Numerical integration: idpoint rule, Trapezoidal rule, Simpson's rule, Simpson's $\frac{3}{8}$-rule, Boole's rule, composite trapezoidal rule, composite Simpson's rule.

UNIT-IV

Ordinary differential equations, Euler's method, Taylor series method, Runge-Kutta methods, linear multi-step methods: Adams-Bashforth methods and Adams-Moulton methods.

Textbooks

1. M. K. Jain. S. R.K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, 7^{th} Ed., 2019.
2. Richard L. Burden and J. Douglas Faires, Numerical Analysis, 9^{th} Edition, Cengage Learning, 2012.

Reference Books

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, 2007.
2. K. E. Atkinson, An Introduction to Numerical Analysis, 2^{nd} Ed., Wiley, 1989.

UC-BSM-504-19	Partial Differential Equation (PDE)	L-4, T-1, P-0	4 Credits

Pre-requisite: Calculus of several variables and ODE

Course Objectives: The objectives of this course are to:

1. Introduce Partial differential equations and different methods to solve it.
2. Derive heat and wave equations.
3. Find the solutions of PDEs with boundary conditions.
4. Learn the technique of separation of variables to solve PDEs and analyze the behavior.
5. Develop the skills that will allow students to work effectively with the concepts.

Course Outcomes: At the end of the course, the students will be able to

CO1	Solve linear partial differential equations of both first and second order.
CO2	Classify the Partial differential equations.
CO3	Apply problem-solving using concepts and techniques from PDE's and Fourier analysis applied to diverse situations in physics, engineering and in other mathematical contexts.
CO4	Demonstrate accurate and efficient use of Fourier analysis techniques and their applications in the theory of PDE's.
CO5	Solve real problems by identifying them appropriately from the perspective of partial derivative equation.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**5**	**-**	**-**	**-**	**5**
CO2	**5**	**-**	**-**	**-**	**5**
CO3	**5**	**-**	**-**	**-**	**5**
CO4	**5**	**-**	**-**	**-**	**5**
CO5	**5**	**-**	**-**	**-**	**5**

Course Title: Partial Differential Equations (PDE)

Course Code: UC-BSHM-504-18

UNIT-I

Introduction of a PDE, Surfaces and Normals, Formation of PDE, Solution of PDE of first order, Lagrange's method, Integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces. Non-linear partial differential equation of the first order, Cauchy method of characteristics, compatible systems of first order equations, Charpit's method.

UNIT-II

Classification of a second order PDE, Elliptic equations: Derivation of Laplace equation, Boundry value problems, Method of separation of variables, Solution of Laplace equation in cylindrical and spherical coordinates.

UNIT-III

Parabolic differential equations: Occurrence of diffusion equation, Boundary conditions, Solution by separation of variables method, Solution of diffusion equation in cylindrical spherical coordinates**.**

UNIT-IV

Hyperbolic differential equation: Derivation of one - dimensional wave equation, vibrating string-variables separation solution, Periodic solution of one - dimensional wave equation in cylindrical and spherical polar coordinates.

Books Recommended:

1. K. Sankara Rao, Introduction to Partial differential Equations (Second Edition), PHI.
2. Walter A. Strauss, Partial differential equations An Introduction, John Wiley and Sons.
3. Sneddon I. N, Elements of Partial differential equations, Dover Publications, Inc. Newyork, 2006.
4. Ross S. L, Differential equation. 3rd Ed., John Wiley and Sons, India, 2004.

UC-BSHM-601-19	**Number Theory**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Numbers system and Basic operations on numbers.

Course Objectives: The objectives of this course are to:

1. Introduce the fundamental concepts of the Number theory
2. Develop understanding of the fundamental concepts of Number theory such as Fundamental theorem of arithmetic, congruences etc.
3. Develop the skills that will allow students to apply the concepts in real life problems.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand well ordering principle, Archimedean Property, Binomial theorem, Triangular number
CO2	Describe basic properties of GCD and LCM and having the ability to compute them.
CO3	Decide the primality of a given number and be able to understand the concept of infinite primes.
CO4	Apply Chinese remainder theorem.
CO5	Understand the utility of Divisibility tests.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	3	3	2	2	3
CO2	3	2	2	2	3
CO3	3	2	2	2	3
CO4	2	3	2	2	3
CO5	3	2	2	2	3

Course Title: Number Theory

Course Code: UC-BSHM-601-19

UNIT-I

Earlier Number Theory: Well ordering Principle, Archimedean Property, Principle of finite induction, Binomial theorem, Triangular number, Sum, difference, and product of triangular numbers.

UNIT-II

Divisibility Theory: division Algorithm, Greatest common divisor (GCD) and its properties, Euclid's Algorithm, Least common multiplier and its properties, Relation between GCD and LCM, Linear Diophantine equations and their solutions.

UNIT-III

Primes and their Distribution: Fundamental theorem of arithmetic, irrational numbers, Sieve of Eratosthenes to check the primality, Golbach conjecture, Euclid's Infinite prime number theorem, Product of consecutive 'r' integers.

UNIT-IV

Theory of Congruences: Basic properties of congruences, Special divisibility tests, Linear congruences and their incongruent solutions, Chinese remainder theorem.

RECOMMENDED BOOKS:

1. David M. Burton, Elementary Number Theory, 7th Ed., Tata McGraw-Hill, 2007, Print.
2. Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., 2007. Print.

UC-BSM-602-19	**Complex Analysis**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Complex numbers system and Calculus of several variables.

Course Objectives: The objectives of this course are to:

1. Introduce the fundamental ideas of the functions of complex variables
2. Develop understanding of the fundamental concepts of Complex Analysis such as analytic functions, complex integrals etc. and
3. Learn the technique to solve the problems using Cauchy's theorem, Cauchy's integral formula etc.
4. Develop the understanding to solve the problems of Contour Integration.
5. Develop the skills that will allow students to work effectively with the concepts.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand Complex functions, Its continuity and differentiability.
CO2	Describe basic properties of complex integration and having the ability to compute such integrals.
CO3	Decide when and where a given function is analytic and be able to find its series development.
CO4	Apply residue theorem to compute the several kinds of real integrals.
CO5	Understand the concept of conformal transformation and bilinear transformation.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**5**	**-**	**-**	**-**	**5**
CO2	**5**	**-**	**-**	**-**	**5**
CO3	**5**	**-**	**-**	**-**	**5**
CO4	**5**	**-**	**-**	**-**	**5**
CO5	**5**	**-**	**-**	**-**	**5**

Course Title: Complex Analysis

Course Code: UC-BSHM-602-18

UNIT-I

Function of complex variables, limit, continuity and differentiability. Analytic functions, Harmonic functions, Cauchy - Riemann equations (Cartesian and Polar form), sufficient condition for differentiability, Construction of analytic functions.

UNIT-II

Curves, simply closed curves, Complex line integral, Path independence of a line integral, Cauchy's theorem, Cauchy's integral formula and Applications. Liouville's theorem and its consequences.

UNIT-III

Taylor's theorem, Laurent's theorem and their examples. Zeros and singularities of an analytic function, Residue at a pole and at infinity, Cauchy's Residue theorem.

UNIT-IV

Evaluation of definite integrals, Integration round the unit circle, Evaluation of the integral of the form $\int_{-\infty}^{\infty} f(x)dx$, Jordan's Inequality, Jordan's lemma , Integral of the form $\int_{-\infty}^{\infty} \frac{P(x)}{Q(x)} \sin mx\, dx$ etc.

Books Recommended:

1. Copson, E. T.: Theory of functions of complex variables. Oxford university press.
2. Grewal, B.S.: Higher Engineering Mathematics, Khanna Publishers.
3. Conway, J. B. : Functions of one complex variable(Second Edition), Springer.
4. Brown J. W. and Churchill R. V. : Complex variables and applications (Eighth Edition) Mcgraw-Hill Higher Education.
5. Kasana, H.S : Complex-Variable , Theory and Applications, PHI.
6. Ponnusamy S: Foundations of Complex Analysis, Narosa Publishing House.

UC-BSM-603-19	Mechanics	L-4, T-1, P-0	4 Credits
Pre-requisite: Sets, Relations and Functions			

Course Objectives: The objectives of this course are to:

1. Develop understanding of concept of force, coplanar, concurrent forces, their resultant.
2. Develop concept of static equilibrium and the governing laws of equilibrium.
3. Introduce the concept of Friction, kinds of friction and its laws.
4. Develop understanding of the basic laws of mechanics governing the motion of the particle.
5. Introduce the law of energy and its principles.
6. Develop understanding for solving real life mechanics problems related to science and engineering.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the system of different forces and its effect on the physical body.
CO2	Understand the various concepts of statics and dynamics.
CO3	Understand the various mathematical laws of mechanics dealing with the motion of the particle and the static equilibrium.
CO4	Apply the knowledge of Mechanics in solving real life problems related to mechanics.
CO5	Visualize the real life mechanical problems related to science and engineering and frame the mathematical problems along with suggested solutions.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**-**	**5**	**-**	**-**	**5**
CO2	**-**	**5**	**-**	**-**	**5**
CO3	**3**	**5**	**-**	**-**	**5**
CO4	**-**	**5**	**-**	**-**	**5**
CO5	**3**	**5**	**-**	**-**	**5**

Course Title: Mechanics

Course Code: UC-BSHM-603-18

UNIT-I

Concept of Force and the system of forces, Resultant of the Force system, Coplanar and concurrent force system and their resultant, resolution and composition of forces, turning effect of forces, resultant of coplanar non-concurrent force system, funicular polygon, concept of equilibrium, possible displacements of a body, conditions of equilibrium for coplanar force system, body constraints and free body diagrams, reactions.

UNIT-II

Gravity and gravitational force, centre of gravity, centroid, Location of centre of gravity of solids, location of centre of gravity through method of integration, Friction, laws of friction, coefficient of friction, moment of frictional force, rough inclined plane.

UNIT-III

Motion of particles, rectilinear motion of particles, curvilinear motion of particles, kinematics of rigid bodies, Newton's laws of motion, equation of motion, linear momentum of particle, impulse and momentum, conservation of linear momentum, D'Alembert's Principle, circular motion.

UNIT-IV

Work, energy their Principles and applications to rigid bodies undergoing rectilinear and curvilinear translations. Applications of work and energy principle to bodies undergoing rotation about a fixed axis, potential energy, conservation of energy, power.

Textbooks

1. M. M. Malhotra, R. Subramanian, P. S. Gahlot, B. S. Rathore: Textbook in Applied Mechanics, New Age International, 2003.

Reference Books

1. Dynamics by A. S. Ramsey, Cambridge University Press.
2. The Elements of Statics and Dynamics: Part 2 (Dynamics) by S. L. Loney, Arihant Prakashan, Meerut.

UC-BSHM-604-19	Discrete Mathematics	L-4, T-1, P-0	4 Credits

Pre-requisite: Numbers system and Primality.

Course Objectives: The objectives of this course are to:

1. Introduce the basic ideas of sets, relations and functions.
2. Develop understanding of the fundamental concepts of Basic Counting principles.
3. Develop the skills that will allow students to work effectively with the concepts.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand sets, relations, and functions.
CO2	Describe basic properties of graph theory.
CO3	Decide when and where a given function is one-one, onto.
CO4	Apply logics for inferences.
CO5	Understand the applicability of basic counting principles in daily life problems.

Mapping of course outcomes with the program outcomes

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	3
CO2	3	2	2	2	3
CO3	3	2	2	2	3
CO4	2	3	2	2	3
CO5	3	2	2	2	3

Course Title: Discrete Mathematics

Course Code: UC-BSHM-604-19

UNIT- I

Set Theory, Relations and Functions: Sets, Algebra of Sets, Ordered Sets, Subsets, Relations, Equivalence Relations and Partitions, Hasse diagram, Functions, Composition of Functions, One-One, onto and Inverse of a function Number of one-one functions.

UNIT-II

Basic Counting Principles and Recurrence Relations: Permutation, Combinations, Pigeonhole Principle, Inclusion-exclusion Principle, Recurrence Relations, Characteristic Equation, Homogeneous and non-homogeneous linear recurrence relations with constant coefficients, Generating Functions for some standard sequences.

UNIT-III

Graphs Theory and Basic Terminology: Simple graphs, Multiple graphs, Connected graphs, Complete graphs, Handshaking Theorem, Isomorphism of Graphs, Walks, Paths, Circuits, Eulerian and Hamiltonian Paths, Planar and Non Planar Graphs, Shortest path, Directed graphs, Travelling Salesman Problem.

UNIT-IV

Logic and Boolean algebra: Propositions, Basic logic operators, Logic equivalence involving Tautologies and Contradiction, Conditional Propositions, Quantifiers, Introduction to Boolean algebra, Laws of Boolean algebra, Boolean function, Sum of product form, Logic gates and circuits.

RECOMMENDED BOOKS:

1. K. H. Rosen, Discrete Mathematics and its Applications, 6th Edition, McGraw Hill, 2007.
2. S. Lipschutz and M. L. Lipson. Schaum 's Outline of Discrete Mathematics, Schaum 's Outlines, 2007. Print.
3. B. Ram, Discrete Mathematics. Pearson Publications, 2011. Print.
4. C. L. Lui, Elements of Discrete Mathematics. McGraw Hill, International Edition, Computer Science Series.1986. Print.
5. J.P. Trembley and R.P. Manohar, Discrete Mathematical Structures with Applications to Computer Science. McGraw Hill, 1975. Print.

UC-BSHM-605-19	**Integral Equations and Integral Transforms**	**L-4, T-1, P-0**	**4 Credits**

Pre-requisite: Differential and Integral Calculus

Course Objectives: The objectives of this course are to:

1. Develop understanding of Integral equations occurring in science and engineering.
2. Introduce Integral Transforms: Laplace Transform and Fourier Transform and also to demonstrate their applications.
3. Develop understanding of applicable mathematics.

Course Outcomes: At the end of the course, the students will be able to

CO1	Understand the significance of Integral equations
CO2	Solve Integral equations and apply the knowledge to real world problems.
CO3	Apply Laplace transform for solving certain differential equations.
CO4	Apply Fourier transform for solving certain differential equations.
CO5	Apply understanding of applicable mathematics for solving problems occurring in science and engineering.

Mapping of course outcomes with the program outcomes

	PSO 1	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO1	**3**	**5**	**-**	**-**	**5**
CO2	**3**	**5**	**-**	**-**	**5**
CO3	**3**	**5**	**-**	**-**	**5**
CO4	**3**	**5**	**-**	**-**	**5**
CO5	**3**	**5**	**-**	**-**	**5**

Course Title: Integral Equations and Integral Transforms

Course Code: UC-BSHM-605-19

UNIT-I

Integral Equations: Definition of Integral equation, Relation between differential and Integral equations, The Green's function, Conversion of boundary value problems to integral equations using Green's function, solution of integral equations, Integral equations of convolution type, Abel's Integral equation, Integro-differential equations.

UNIT-II

Integral equations (Continue): Integral equations with separable kernels, Solution of Fredholm equations with separable kernels, Solution of Fredholm and Volterra equations by the method of successive approximations.

UNIT-III

Laplace Transform Laplace transform and inverse Laplace transform, sufficient conditions for existence of Laplace transform, linearity property, shifting property, change of scale property, Laplace transform of derivatives and integrals, differentiation of Laplace transform, integration of Laplace transform, convolution theorem, Laplace transform of periodic functions, Solution of initial value problems of ordinary differential equations by Laplace transform.

UNIT-IV

Fourier Transform Fourier transform and its inversion formula, linearity property, shifting property, Modulation theorem, Fourier transform of derivative, Fourier transform of integral, convolution, Fourier cosine transform, Fourier sine transform, Solution of some initial-boundary value partial differential equations using Fourier transform.

Textbooks

1. Francis B. Hildebrand, Methods of Applied Mathematics, Prentice-Hall, INC, 1965.
2. B. S, Grewal, Higher Engineering Mathematics, Khanna Publishers, New Delhi
3. R. K. Jain, S. R. K. Iyengar, Advanced Engineering Mathematics, 5th Ed., Narosa, 2019.
4. Baidyanath Patra, An Introduction to Integral Transforms, 1st Ed., CRC Press, 2018.

Reference Books

Lokenath Debnath, Integral Transforms and Their Applications, 3rd Ed., Chapman and Hall/CRC, 2014.