DEPARTMENT OF MATHEMATICS

H N B GARHWAL UNIVERSITY (A CENTRAL UNIVERSITY) SRINAGAR-246174

NEP-2020

Syllabus

BACHELOR'S DEGREE PROGRAMME (4YEARPROGRAMME) WITH HONOURS/RESEARCH (SCIENCE)

FirstYear-Semester-I

Semester-I				
Major Subjects	**Credits**		**Remarks**	
Core Subject-1(CS-1) **Core Subject-2(CS-2)**	6	**Major Paper-I(CS-1)** Differential Calculus	**Total credits of Major Papers = 12 credits**	
Additional/ Interdisciplinary subject/Multidisciplinary	4 Or 2+2	**Additional Course-I,Part-1** (Theory Minor with or without Practical Interdisciplinary/Multidisciplinary-1) Basic Calculus	Students will have to opt 2Additional/ Multidisciplinary paperss of same subject in1stand2ndsemesteror 3rdand4thsemester.	
Skill Course	2	**One Skill/Vocational Course-I** Integral Calculus	**Skill courses of one major subject (Either CS-1 or CS-2) has to be pursued in both semesters i.e.(I &II and of another subject in III &IV semesters)**	

Extra curricular Courses/CC	2	1- **Understanding and connecting with Environment**	
Total	**20**		

Note:Each additional/multidisciplinary course will only be of two semesters.The course opted by a student in first semester will be continued in the second semester.The student will have the choice to select another Multidisciplinary course in third semester which Will again be continued in fourth semester.

FirstYear-Semester-II

Semester-II			
MajorSubjects	**Credits**		**Remarks**
Core Subject-1(CS-1) **Core Subject-2(CS-2)**	6	**MajorPaper-II (CS-1)** Differential Equations	**Total credits of Major Papers=12credits**
Additional/Interdisciplinarysubject/Multidisciplinary	4 Or 2+2	**Additional Course-I, Part-2** **Theory Minor with or without Practical(Interdisciplinary/Multidisciplinary-1contd.)** Basic Differential Equations	
SkillCourse	2	**OneSkill/ VocationalCourse-I** Vector Calculus	**Skill course of one major subject has to be pursued in both semesters i.e.(I &II and of another subject in III &IV semesters)**
LifeSkillsandpersonalitydevelopment/CC	2	Life Skills and personality development	
Total	**20**		
Note:	In case of exit after completion of first year/second semester,student will be awarded Certificate on the basis of Core and vocational papers studied by him.Nomenclature will be given with syllabus of each subject.Award of certificate is subject to fulfillment of the conditions as laid down in NHEQF.		

For Example: Under Graduate Certificate course in Life Science (Zoology and Botany)/Under Graduate Certificate course in Sciences(Physics and Chemistry/ Physics and Maths)/Under Graduate Certificate course in Earth Sciences(Geology and Geography).

SecondYear-Semester-III

Semester-III			
MajorSubjects	**Credits**		**Remarks**
Core Subject-1(CS-1) **Core Subject-2(CS-2)**	6	**Major Paper-III(CS-1)** Real Analysis	**Total credits of Major Papers=12credits**
Additional/Interdisciplinarysubject/Multidisciplinary	4 Or 2+2	**Additional Course-I, Part 3** **TheoryMinor with or without** **Practical** **(Interdisciplinary/Multidisciplinary-2)** Ancient Indian Mathematics	
SkillCourse	2	**One Skill/Vocational** **Cou rse-II**	**Skill course of another subject(CS-1 or CS- 2)will be pursued in3rd and4th semester .**
IKS-1	2	**Indian Knowledge System-I**	**Compulsory for all U.G.students**
Total	**20**		
Note:Each multidisciplinary course will only be of two semesters.The course opted by a student in first semester will be continued in the second semester. The student will have the choice to select another Multidisciplinary course in third semester which will again be continued in fourth semester.			

SecondYear-Semester-IV

Semester-IV			
MajorSubjects	**Credits**		**Remarks**
Core Subject-1(CS-1) **Core Subject-2(CS-2)**	6	**MajorPaper-IV(CS-1)** Abstract Algebra	**Total credits of Major Papers=12credits**
Additional/Interdisciplinarysubject/Multidisciplinary	**4** **Or** **2+2**	**Additional Course-I,** **Part 4** **Theory Minor with or without Practical (Interdisciplinary/Multidisciplinary-2contd..)** Basic Statistics	**In case of additional interdisciplinary course,part4ofsamesubject which is opted by student in 1ˢᵗsemester will be continued.** **Subject of the Multidisciplinary course opted by the student in 3ʳᵈsemester will be con tinued in 4ᵗʰ semester as Part 2**
SkillCourse	**2**	**OneSkill/ VocationalCourse-II contd…**	**Skill course of 3ʳᵈ semester will be continued in 4ᵗʰ semester as part2.**
IKS-2	2	**IndianKnowledgeSystem-II**	**CompulsoryforallU.G.students**
Total	**20**		
Note:Each multidisciplinary course will only be of two semesters.The course opted by a student in 3ʳᵈsemester will be continued in the 4ᵗʰsemester.			

CompulsoryCommunityconnectCourse
Student will have to qualify a Compulsory Community Connect/Social Service Program/ Minimum 16 hours of service within any semester(ItoIV).This course will be based on communit yconnect,swaach bharat,ek bharat ,shrestra bharat,NSS etc.It will b e based on number of hours devoted under this course.Concerned department will verify the fulfilment of minimum hours towards CCS.

After completion of 2 years of study, if student opts exit then a Diploma will be awarded subject to fulfilment of the conditions as laid down inNHEQF. Nomenclature of Diploma course will be given in syllabus of each subject. For Example: Under Graduate Diploma course inLifeScience (Zoology and Botany)/Under Graduate Diploma course inSciences (Physics and Chemistry/ Physics and Maths)/ Under GraduateDiplomacourse inEarthSciences(GeologyandGeography)

ThirdYear-Semester-V

Semester-V			
MajorSubjects	**Credits**		**Remarkss**
Core Subject-1(CS-1)	4+2	**Major Paper-V (CS-1)** Linear Algebra	**Majorpapersof samecoresubjectsasoptedby studentwillcontinued.**
Core Subject-2(CS-2)	4+2	**MajorPaper-V-(CS-2)** Theory-1 Practical-1	
Vocational Course/FieldVisit/ Entrepreneurshipskills	4	**Vocational course/Field Visit/ Entrepreneurship/Academic-Industry interface Course**	**(Related to any one major either CS-1 or CS-2) A Vocational Course can be framed/ opted by the department. (OR) Field visits could be conducted for students as per requirement of their core papers.In case of Field/industrial visits, the Student Will have to submit a brief report at the end of the semester.**
ExtracurricularCourses/Compulsorycourse	2	**Culture, traditions and moral values**	
Languages-I	2	**Indian, Modern, Regional Language-I**	**Aim of the course- to help student to learn new languages(Focusing mainly on grammar).** **Students will have the option to study any two languages in two semesters separately.(Hindi/Sanskrit/English/any other language as proposed by the university)**
Total	**20 credits**		
Note:Studentwillhavetheoptiontostudyonelanguage(Indian,ModernorRegionalasperhis/herchoice)inonesemesterand anotherlanguageinthesubsequentsemester.			

ThirdYear-Semester-VI

Semester-VI			
MajorSubjects	**Credits**		**Remarkss**
Core Subject-1(CS-1)	**4+2**	**DSE-Paper(CS-1)** Complex Analysis (Theory-1)	**Department will prepare a basket of Discipline specific Elective courses (3-4).** **Anyone will be selected by student in this semester.**
Core Subject-2(CS-2)	**4+2**	**DSE-Paper(CS-2)** Theory-1 Practical-1	
Vocational Course/FieldVisit/ Entrepreneurshipskills Basedon: eitherCS-1orCS-2	4	**Vocational course/Field Visit/ Entrepreneurship/Academic-Industry interface Course**	**(Related to any one major either CS-1 or CS-2) A Vocational Course can be framed/ opted by the department. (OR) Field visits could be conducted for students as per requirement of their core papers. In case of Field/industrial visits, the Student will have to submit a brief report at the end of the semester.**
Communicationskills/CC	**2**	**Communication skill Course (Based on developing soft skills)**	
Languages-II	2	**Indian, Modern, Regional Language-II**	**Aim of the course- to help student to learn new languages(Focusing mainly on grammar).** **Student will have the option to study any two languages in two semesters separately.(Hindi/Sanskrit/English/any other language as proposed bythe university)**
Total	**20**		
Note: Student will have the option to study one language (Indian, Modern or Regional as per his/her choice) in one semester and another languageinthe subsequent semester.			

IncaseofExitafter3ʳᵈyearGraduatedegreewillbeawarded   (Example-BSc)(Credits-120)

FourthYear-Semester-VII(withResearch)

Semester-VII			
MajorSubject(OneOnly)			
	3+3+2	**MajorPapers-2with3crediteachand 1 Practicalbasedonbothpaperswith2credits(Practical subjects)** **OR** **Major papers - 2of4creditseachfornonpracticalsubject(Maths /Statistics)** **Major Paper –I: Numerical Analysis** **Major Paper –II: Integral Transforms**	**Theses papers will be based on core subject selected By the students for PG Research(Zoology/Botany.Physi**
ResearchMethodology	**4**	**Research Methodology**	Studentwilllearnthebasicresearchmethodologywithfocus on data analysis which he/she could apply in research-based work that he/she will carry out in VIII semester. **Eachdepartmentwillprepareitssyllabusbasedontheir Subject requirements**
Electivepaper	**3+3**	**Electivepaper** **1 Theoryand1Practical(3creditseach)** **OR 2 Elective Theory papers for Non-practical subject.** **Paper-I: Metric Space** **Paper-II: Financial Mathematics** **Paper III: Mathematical Statistics** **Paper IV: Fluid Dynamics** **Paper V: Number Theory**	**Studentwillhavetoselectelectivepapersfromthebasket prepared by each department for this purpose.ThesepapersmaybeDSEs**
Researchwriting andEthics	**2**	**1-Researchwriting andresearchEthics**	
Total	**20**		

FourthYear-Semester-VIII(withResearch)

Semester-VIII			
MajorSubject(OneOnly)			
		MajorPapers-2with3crediteachand 1Practicalbasedonbothpaperswith2credits(Practicalsubjects) **OR** **Majorpapers - 2of4creditseachfornonpracticalsubject(Maths/Statistics)** **Paper-I: Discrete Mathematics** **Paper-II: Operations Research-1**	**Theses papers will be based on core subject selected**
Researchpresentationskills	2	**ResearchPaperpresentationskills (OralandPoster)**	**.Compulsory**
Electivepaper	3+3	**Electivepaper 1Theoryand1Practical(3creditseach)** **OR 2 Elective Theory papers** **for Nonpracticalsubject.** **Paper-I: Metric Space** **Paper-II: Financial Mathematics** **Paper III: Mathematical Statistics** **Paper IV: Fluid Dynamics** **Paper V: Number Theory**	**Studentwillhavetoselectelectivepapersfromthebasket prepared by each department for this purpose.Thesesmaybe DSEs**
Dissertation	4	**Dissertation/ Researchbased field or industrialreport**	Studentwillconductminorresearchworkandwillsubmit thedissertationattheendofsemesterorwilldoresearch
			basedfieldstudy
Total	**20**		
Afterthecompletionof8semesterswithabovementionedpapersthestudentwillbeawardedU.G.degreewithresearch.Afteravailingthisdegree studentwillhavetheoptionto go foroneyearP.G.Course/PhD			

Fourth Year-Semester-VII(Honours)

Semester-VII			
MajorSubject(OneOnly)			
MajorCore-	4+4	**MajorPapers-** **1 Theoryand1 Practical** **with4 credits each(Practical subjects)** **OR** **2 Theory papers for non- practical subject(Maths/Statistics,etc)** **Major Paper –I: Numerical Analysis** **Major Paper –II: Integral Transforms**	**Theses papers will be based on core subject selected by the students for PG and Research(Zoology/Botany.Physics/Chemistry/Maths,etc.)**
MajorElective	4	**Therewillbe1Majorelectivefromcorepaper Theory and Practical(2+2)OR1Theory (4)** **Mathematical Statistics**	**These will be from main core paper**
MinorCore	3	**Minor core Paper(1)of 3 credits** **Metric Spaces**	**Studentwillhavetooptthispaperfrom**
		(without practical)	**othersubjectstudiedbyhiminUG1ˢᵗand2ⁿᵈ year**
Minor Elective	3	**Minor Elective Paper(1) of 3 credits** **with out practical)** **Special Functions**	**Student will have to opt this paper from other subject studied by him in UG 1ˢᵗand2ⁿᵈyear**
Research writing and ethics	2	**1.Core paper**	
Total	**20 credits**		

Fourth Year-Semester-VII I(Honours)

Semester-VIII			
MajorSubject(OneOnly)			
MajorCore-	4+4	**MajorPapers-** **1Theory and1Practical with 4 credits each(Practical subjects)**	Thesespaperswillbebasedoncoresubject selected by the students for PGandResearch(Zoology/Botany.Physics/Chemistry/Maths,etc.)

		OR **Theorypapersfornon-practicalsubject(Maths/Statistics,etc)** **Paper-I: Discrete Mathematics** **Paper-II: Operations Research**	
MajorElective	4	**Therewillbe1Majorelectivefromcorepaper** **Theory andPractical(2+2)OR1Theory (4)** **Fluid Dynamics**	**Thesewillbefrommaincorepaper**
MinorCore	3	**MinorcorePaper(1)of3 credits** **(withoutpractical)** **Number theory**	**Student will have to opt this paper fromother subject studied by him in UG 1ˢᵗand2ⁿᵈyear**
MinorElective	3	**MinorElectivePaper(1)of3credits(wit** **houtpractical)**	**Student will have to opt this paper fromother subject studied by him in UG 1ˢᵗand2ⁿᵈyear**

		Financial Mathematics	
BasicResearchMethods	**2**	**OneCorepaper**	
Total	**20**		

(Syllabus under NEP-2020)
Session: 2022-23
B.A./B.Sc.(Mathematics) Syllabus
H.N.B. Garhwal University, Srinagar (Garhwal) U. K.

Semester	Core Subject-1	Additional/Interdisciplinary /Multidisciplinary course	Skill/Vocational Course-I
I	Differential Calculus (Theory-Credits-06)	Basic Calculus	Integral Calculus(Either in I or III Semester)
II	Differential Equations (Theory-06 Credits)	Basic Differential Equations	Vector Calculus(Either in II or IV Semester)
III	Real Analysis (Credit-06 ,Theory-05+Tutorial-01)	Ancient Indian Mathematics	
IV	Abstract Algebra (Credit-06 , Theory-05+Tutorial-01)	Basic Statistics	
V	Linear Algebra (Theory-06 Credits)		
VI	Complex Analysis (Theory-1-06 Credits)		

Fourth Year (with Research)

Semester	Major Subject : Core	Research Methodology	Elective Papers
VI	Major Paper–I: Numerical Analysis (04-Credit) Major Paper–II: Integral Transforms (04-Credit)	Paper I: Research Methodol ogy (04-Credit) Paper II: Research writing and Ethics (02-Credit)	Paper-I: Metric Spaces Paper-II: Financial Mathematics Paper III: Mathematical Statistics Paper IV: Fluid Dynamics Paper V: Number Theory

VIII	Paper-I: Discrete Mathematics Paper-II: Operations Research-1		Paper-I: Metric Spaces Paper-II: Financial Mathematics Paper III: Mathematical Statistics Paper IV: Fluid Dynamics Paper V: Number Theory

Fourth Year(Honours)

Semester	Major Subject Cor e	Major Elective	Minor Core	Minor Elective
7	Major Paper–I: Numerical Analysis (04-Credit) Major Paper–II: Integral Transforms (04-Credit)	Mathematical Statistics (04 Credit)	Metric Spaces (03 Credit)	Special Functions (03 Credit)
8	Paper-I: Discrete Mathematics Paper-II: Operations Research-1	Fluid Dynamics (04 Credit)	Number theory (03 Credit)	Financial Mathematics (03 Credit)

Semester-I

CS-1: Differential Calculus

Theory (06-Credits)

Unit-I: Limit and Continuity (ε and δ definition), Types of Discontinuities, Differentiability of functions, Rolle's theorem, Lagrange's Mean Value theorems, Cauchy Mean Value Theorem.

Unit-II: Successive differentiation, Leibnitz's theorem, Taylor's theorem with Lagrange's and Cauchy's forms ofremainder, Taylor's series, Maclaurin's series of sin x, cos x, e^x, $\log(l+x)$, $(1+x)^m$

Unit-III: Indeterminate forms. Partial Differentiation, Euler's Theorem for Homogeneous function, Maxima and Minima of Functions of Two Variables.

Unit-IV: Tangents and normal, Curvature. Asymptotes, Singular Points, Tracing of Curves in Cartesian and Polar Coordinates.

Books Recommended
1. H. Anton, I. Bivens and S. Davis,*Calculus*, John Wiley and Sons, Inc., 2011.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education,2007.

Additional course-Part-1
Basic Calculus (04- Credits)

Unite-I: Limit, Continuity and Differentiability
Unite-II: Rolle's Theorem, Lagrange's Mean Value theorems, Cauchy Mean Value Theorem.Expansion of functions, Taylor's and Maclaurin'sSeries of Functions.

Unit-III: Indeterminate Forms. Partial Differentiation, Euler's Theorem for Homogeneous Function,

Unit-IV: Maxima and Minima of Functions of two variables. Tangents and Normal.

Books Recommended

1. H. Anton, I. Bivens and S. Davis,*Calculus*, John Wiley and Sons, Inc., 2011.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education,2007.
3. Tom M. Apostol, Calculus Vol. I, John Wiley & Sons, Inc. 2007.

Skill Course-I
Integral Calculus (02-Credits)

Unit-I: Integration of rational and irrational functions, Properties of definite integrals.
Reduction formulae for integrals of rational and trigonometric functions,

Unit-2: Gamma and Beta functions. Areas and lengths of curves in the plane, Volumes and surfaces of solids of revolution. Double and tripleintegrals.

Books Recommended

1. G.B. Thomas and R.L. Finney,*Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H.Anton,I.BivensandS.Davis,*Calculus*,JohnWileyandSons(Asia)P.Ltd.,2002.

Semester-II
Core Subject 1: Differential Equations
(Theory-06 Credits)

Unit-I: Classification of differential equations: their origin and applications, initial value problems, boundary value problems, existence of solution. Separable equation and reducible to this form.

Unit-II: Exact differential equation, integrating factors, special integrating factor and transformations.linear differential equation and Bernoulli equations, first order higher degree equations solvable for x, y, p.

Unit-III: Higher-order differential equations with constant coefficients, basic theory of linear differential equations, The Cauchy-Euler equation, Simultaneous differential equations. Wronskian and its properties Second order linear differential equations with variable coefficients, Inspection Method, Reducible to normal form, Change of Independent Variable, Variation of Parameters. Total differential equations.

Unit-IV: Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons,1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition,1967.

Additional course-Part-2
Basic Differential Equations (04 credits)

Unit-I: Classifications of Differential equations, their origin and and applications, initial value problems.

Unit-II: Exact differential equations of first order, Integrating factors,special integrating factor and transformations,Linear differential equations and Bernoulli equation.

Unit-III: First order higher degree equations solvable for x,y,p. Higher order differential equations with constant coefficients.

Unit-IV: Order and degree of partial differential equations,Concept of linear and non-linear p.d.e. ,formulation

of first order partial differential equations.

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition, 1967.

Skill Course-II
Vector Calculus (02 Credits)

Unit-I: Scalar and vector products of three and four vectors, Reciprocal systems of vectors, Applications of vectors to three dimensional geometry. Differentiation of vectors, partial differentiation of vectors, Velocity and acceleration, Integration of vectors.

Unit-II: Differential operators, Gradient of a scalar point function, Directional Derivatives,Divergence and Curl of vectors. Line integrals, Surface integrals, Applications of Gauss's , Green's and Stokes theorems.

Books Recommended
1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd. 2002.
3. P.C. Matthew's, Vector Calculus, Springer Verlag London Limited, 1998.

Semester-III
Major Paper-III(CS-1)
Real Analysis (Theory-1, 06 credits)

Unit I: Finite and infinite sets, Examples of countable and uncountable sets, Real line, Bounded sets, Supremum and infimum, Completeness property of R, Archimedean property of R, intervals, Concept of limit points and Bolzano-Weierstrass theorem.

Unit II: Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences, Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence , monotone convergence theorem.

Unit III: Infinite series. Cauchy convergence criterion for series, Positive term series, Geometric series, Comparison test, p-test, Root test, Ratio test, Alternating series, Leibnitz's test, Cauchy Condensation test, absolute and conditionalconvergence.

Unit IV: Riemann integral : Definition and examples, Properties of Riemann integrals, Necessary and sufficient conditions for inerrability, Fundamental theorem of Calculus.

Books Recommended
1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd.,2002.
2. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd., 2000.
3. K.A. Ross, Elementary Analysis- The Theory of Calculus Series-
Undergraduate Texts in Mathematics, Springer Verlag, 2003.

Additional Course
Part 3
Ancient Indian Mathematics (04 Credits)
Unit-I: Multiplication
1. Ekadhikenpurven method (multiplication of two numbers of two digits)

2. Eknunenpurven method (multiplication of two numbers of three digits)

3. Urdhvatiragbhyam method (multiplication of two numbers of three digits)

4. NikhilamNavtashchramamDashtaha (multiplication of two numbers of three digits)

5. Combined Operations
Unit-II: Division and Divisibility
Part A: Division
1. NikhilamNavtashchramamDashtaha (two digits divisor)

2. ParavartyaYojyet method (three digits divisor)
Part B: Divisibility
1. Ekadhikenpurven method (two digits divisor)

2. Eknunenpurven method (two digits divisor)

Unit-III: LCM and HCF
Unit-IV: Power and Root
Power: (i) Square (two digit numbers), (ii) Cube (two digit numbers).
Root: (i) Square root (four digit number) (ii) Cube root (six digit
numbers) **Unit-V: Work of Indian Mathematicians in Arithmetic**
1. Aryabhatt

2. Brahmagupt

Recommended Books:
1. Vedic Mathematics, *MotilalBanarsi Das, New Delhi.*
2. Vedic Ganita: Vihangama Drishti-1, *SikshaSanskritiUthana Nyasa, New Delhi.*
3. Vedic GanitaPraneta, *SikshaSanskritiUthana Nyasa, New Delhi.*
4. Vedic Mathematics: Past, Present and Future, *SikshaSanskritiUthana Nyasa, New Delhi.*
5. Leelavati, *ChokhambbaVidyaBhavan, Varanasi.*
6. Bharatiya Mathematicians, *Sharda Sanskrit Sansthan, Varanasi.*

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Skill Course-I
Integral Calculus (02-Credits)
(If not opted in semester I)

MajorPaper-IV(CS-1)
Abstract Algebra
(Theory- 06 Credits)

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Unit I: Definition and examples of groups, Examples of abelian and non-abelian groups, the group
Zn of integers under addition and multiplication modulo n, Cyclic groups, Complex roots of unity, Circle group.
Unit II: The general linear group GLn (n,R), Groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle,(iii) a rectangle, and (iv) a square, Permutation groups, Even and odd permutations, Group of quaternions.
Unit III: Homomorphism and isomorphism of groups, Subgroups, Necessary and sufficient condition, Examples of subgroups including the center of a group, Order of an element , Cosets, Index of subgroup, Lagrange's theorem, Normal subgroups: Definition and examples and characterizations, Quotient groups.
Unit IV: Definition and examples of rings, Examples of commutative and non-commutative rings:
rings from number systems, Zn the ring of integers modulo n, Ring of real quaternions, Ring of matrices, Subrings and ideals, Integral domains and fields, Examples of fields: Zp, Q, R and C.
Books Recommended
1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1999.

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Additional Course-
Part 4
Basic Statistics (04 Credits)

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Unit-I Measure of central tendency and dispersion, merits and demerits of these measures. Moments and factorial moments.Shephard's correction for moments.Skewness and Kurtosis and their Measures. Measures based on quartiles. Bivariate data.
Unit II: Basic Probability, Conditional probability, Bayes Theorem.

Unit III: Discrete and Continuous, random variables, probability mass function, probability density function, expectations and moment generating functions.
Unit IV: Method of least squares for curve fitting. Correlation and regression, rank Correlation (

Spearman's and Kendall's measure), Intra-class correlation, correlation ratio.
 TEXT/REFERENCE BOOKS
   1.   Fundamental of Mathematical Statistics : S.C. Gupta and V.K. Kapoor, S. Chand.

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Skill Course-II
Vector Calculus (02-Credits)
(If not opted in semester II)

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Semester-V
Major Paper-V(CS-1)
Linear Algebra (Theory- 06 credits)

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Unit I: Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of Vectors, Linear span, Linear independence/dependence, Basis and dimension, Dimension of subspaces.
Unit II: Linear transformations, Null space, Range, Rank and nullity of a linear transformation, rank-nullity theorem, Isomorphism, Isomorphism theorems, Inevitability and isomorphism.

Unit III: Matrix representation of a linear transformation, Algebra of linear transformations, Dual
space, Dual basis, Double dual, Annihilator.

Unit IV: Eigen value and eigen-vectors of Linear Transformation, Characteristics polynomial, algebraic and geometric multiplicities of eigen-value, Applications of eigen-value and eigen-vectors in finding the power of Matrix A, exp(A), sin(A), cos (A), and p(A), similar Matrices, diagonalization of matrix.

Books Recommended
1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th
Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
2. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education
Asia, Indian Reprint, 2007.
   3. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.

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Semester-VI
DSE-Paper(CS-1)
Complex Analysis (Theory- 06 Credits)

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Unit I: Properties of complex numbers, Regions in the complex plane, Functions of complex variable, Limits, Continuity, differentiability of complex functions, Exponential function, Logarithmic function, Trigonometric function.
Unit II: Differentiability and Analyticity, Cauchy-Riemann Equations, Sufficient conditions for analyticity, Harmonic Functions, Harmonic conjugate function, Applications, Examples of analytic functions.
UnitIII: Contours, Contour integrals and its examples, Upper bounds for moduli of contour integral,Cauchy- Goursat theorem, Cauchy integral formula.Cauchy inequality, Liouville's theorem,Morera's theorem.

Unit IV: Sequences and Series, Taylor Series, Laurent Series, Singularities, Classification of singularities, Residues and Residue theorem.

Books Recommended
1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw-Hill International Edition, 2009.

2. JosephBak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in
   Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. Dennis G. Zill and Patrick D. Shanahan , A First Course in with Applications Complex Analysis, Jones and Bartlett Publishers.

Semester-VII (with Research/Honours)
Major Paper –I: Numerical Analysis (04-Credit)

Unit I: Solutions of algebraic and transcendental equations using Bisection method, False position method, Secant method, Fixed point iteration method, Newton's Rapson method.

Unit II: Solutions of Linear system of equation, Gauss elimination method, LU decomposition, Gauss-Jacobi, Gauss-Siedel and SOR iterative methods.

Unit III: Calculus of Finite differences, Lagrange and Newton interpolation: linear and higher order, finite difference operators.

Unit IV: Numerical differentiation: forward difference, backward difference and central Difference.Integration: trapezoidal rule, Simpson's rule, Euler's method.

Recommended Books

1. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th Ed., New age International Publisher, India, 2007.

Major Paper –II: Integral Transforms (04-Credit)

Unit I: The concept of transform, Integral transforms and kernel, Linearity property of transforms, Laplace transform, properties of Laplace Transform.

Unit II: Inverse Laplace transform, Convolution theorem, Applications of Laplace transform to solve ordinary differential equations.

Unit III: Fourier series, Half range expansions,Fourier integral, Fourier Sine , Fourier Cosine integrals and their properties.

Unit IV: Fourier transform, Applications of Fourier transform to boundary value problems.

TEXT/REFERENCE BOOKS

1. Integral Transforms and Their Applications by LokenathDebnath&bDambaruBhatta, Chapman & Hall/CRC, Taylor and Francis Group , London, New York, 2007.
2. Integral Transforms in Applied Mathematics by John W. Miles, Cambridge University Press,2010.
3. Ian N. Sneddon, Fourier Transforms , Dover Publications,2010 .
4. Advanced Engineering Mathematics by H.K.Dass, S.Chand , New Delhi,2015.

Research Methodology (4-credits)

Unit I: Meaning of research, Empirical and Theoretical research, Inductive and Deductive logics

Unit II: Research hypothesis, Scientific Methods, Research Design, Types of Data & Collection,

Unit III: Sampling, Sampling Distribution, Testing of hypothesis,

Unit IV: Correlation and Regression, Time Series Analysis.

TEXT/REFERENCE BOOKS

1. Research Methodology for Scientists and Engineers: J.N.Kapur
2. Fundamentals of Research Methodology and Statistics: Y.K.Singh, New Age International.

Research writing and research Ethics (02-credits)

Unit I: Research and Publication Ethics: Theory: - Philosophy and ethics, Scientific conduct,

Publication ethics.

Unite II: Research and Publication Ethics: Practice: - Open access publishing, Publication misconduct, Databases and research metrics.

TEXT BOOK

1. Ethics in Research Practice and Innovation, Antonio Sandu, Ana Frunza and Elena Unguru,
IGI Global.
2.Write Mathematics Right by L. Radhakrishna, Narosa Publishng House, 2013

Mathematical Statistics (04 credits)

Unit I: Elements of probability, Sample space, Discrete probability, Baye's theorem, Random variables and distribution functions, Mathematical expectations and moments.
Unit II: Some standard discrete and continuous univariate distributions: Binomial, Poisson, Normal,
Unit III: Correlation, Rank correlation, Regression line, Multiple and partial correlation of three variables only, Data reduction techniques, Canonical correlation.
Unit IV: Concepts of sampling, Stratified sampling and systematic sampling, Test of hypothesis: t,z ,chi square test.

TEXT/REFERENCE BOOKS
2. Fundamental of Mathematical Statistics : S.C. Gupta and V.K. Kapoor, S. Chand.
3. Advanced Theory of Statistics :M.G. Kandall.
4. A first Course on Mathematical Statistics: C.E.Weatherburn, Cambridge Univ. Press, 1968.

Metric Spaces (03 Credits)

Unit I: Metric on a set, Pseudo-metrics, Equivalent metrics, Limit point, Closed sets, Adherent point, Dense subsets, Interior of a set and its properties, Subspaces, Product spaces.
Unit II: Convergent sequences, Cauchy sequences, Algebra of convergent sequences, Subsequences, Continuity at a point, Continuity over a space, Algebra of real valued continuous functions in a metric space, Homeomorphism, Uniform continuity.
Unit III: Complete metric spaces,Completeness and continuous mappings, Cantor's intersection theorem, Contraction mapping theorem, Connectedness in metric spaces, Properties of connectedness.

Unit IV: Compact spaces, Compact subsets of the real line,Compactness and continuous mappings, Sequential compactness, Countable compactness, B-W property, B-W property and boundedness, B-W property and compactness**.**

TEXT/REFERENCE BOOKS
1. Introduction to Topology and Modern Analysis: G.F. Simmons, Tata McGraw-Hill.

2. Metric Spaces: E.T. Copson, Cambridge University Press, 1968.

3. Topology :RobertH.Kasriel, Dover Pub. , 2009.

4. Topology of Metric Spaces: S.Kumaresan, Alpha Science Int. , 2011.

Special Functions (03 Credits)

Unit I: Legendre Polynomial and its properties.
Unit II: Bessel Polynomial, and its properties.
Unit III: Hermite polynomials, and its properties.

Unit IV: Chebyshev polynomials, and its properties.
TEXT/REFERENCE BOOKS

1. The Special Functions and their Applications: Y. L. Luke, Acad. Press, New York.
2. Special Functions: G.E. Andrews, R. Askey, R. Roy, Cambridge Univ. Press.

Financial Mathematics (03 Credits)

Unit I: Single period model, Definitions   of finance- pricing, Forward- one- step binary model, Ternary model- Characterization of no arbitrage, Risk-neutral probability measure

Unit II: Bi normal trees and discrete parameter martingales, Multi-period binary model, American options, Discrete parameter martingales and Markov processes, Martingale theorems, Binomial representation theorem overturn to continuous models

Unit III: Brownian motion, Definition of the process, Levy's construction of brownian motion, The reflection principle and scaling, Martingales, Continuous time.

Unit IV: Stochastic calculus, Non-differentiability of stock prices, Stochastic integration, Ito's formula, Integration by parts and stochastic, Fubini theorem, Girsanov theorem, Brownian martingale representation theorem, Geometric brownian motion, The Feynman- Kac representation.

TEXT/REFERENCE BOOKS

1. A Course in Financial Calculus: Alison Etheridge, Cambridge Univ. Press, 2002.
2. Financial Calculus: An Introduction to Derivatives Pricing : Martin Boxter and Andrew Rennie, Cambridge Univ. Press, 1996.
3. Introduction to Stochastic Calculus Applied to Finance: Damien Lamberton and Bernard Lapeyre, Chapman and Hall, 1996.
4. Martingale Methods in Financial Madeling: MarekMusielaandMarekRuthowshi, SpringerVerlag, New York, 1988.

Number Theory (3 Credits)

Unit I: The division algorithm, The gcd, The Euclidean algorithm, Diophantine equations, The fundamental theorem of arithmetic, The sieve of Eratosthenes, Goldbach conjecture.

Unit II: The theory of congruences,Binary and decimal representation of integers,Linear congruences and Chinese remainder theorem, Fermat's theorem, Wilson's theorem.

Unit III: Number theoretic function, Tau and sigma function, the Mobius inversion formula, The greatest integer function, Euler's phi function, Properties of phi function, Euler theorem.

Unit IV: The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots, The theory of indices, Continued fraction, Approximation of irrationals by rationals.

TEXT/REFERENCE BOOKS

1. Elementary Number Theory: David M. Burton, McGraw-Hill.

2. Theory of Numbers: George Andrews, Courier Corporation, 1994.

3. Elementary Number Theory with Applications: Thomas Koshy, Harcourt Acad. Press.

4. Fundamental of Number Theory:William J. Lereque, Dover Pub. Inc. New York.

Fluid Dynamics (3 Credits)

Unit I: Kinematics of fluids, Lagrangian and Eulerian methods, Local and individual time

rates of change, Equation of continuity, Boundary surface.

Unit II: Equation of motion of inviscid fluids, Euler's equation of motion, Bernoulli's equation, Lagrange's equation, Conservative field of force, Cauchy's Integral, Helm-Holtz's equation.

Unit III: Impulsive motion of a fluid, Energy equation of inviscid fluid, General theory of irrotational motion, Connectivity, Flow and circulation, Kelvin's circulation theorem, Stokes's theorem, Permanence of irrotational motions, Green's theorem, Kinetic energy of finite and infinite liquid, Kelvin's minimum energy theorem

Unit IV: Motion in two dimensions, Stream function, Complex potential, Source, Sink, Doublet, Complex potential and images with respect to straight line and circle, Milne-Circle theorem, Blausius theorem.

TEXT/REFERENCE BOOKS

1. Foundation to Fluid Mechanics: S.W. Yuan, Prentice Hall Pvt. Ltd., 1960.

2. Text book of Fluid Dynamics: F. Chorlton, CBS Pub. & Dist. , 2004.

3. Theoretical Hydro-Dynamics: BansiLal, Skylark Pub., 1999.

4. A text book of Fluid – Dynamics: M. Ray & Sharma, S. Chand & Co. Ltd. 2005.

Semester-VIII (with Research/Honours)
Major Paper –I: Discrete Mathematics (04-Credit)

Unit I: Recurrence relations, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Solutions of recurrence relations.

Unit II: Partially ordered sets, Different type of lattices, Sub-lattices, Direct product, Ideal Lattice, Modular and distributive lattices.

Unit III: Boolean algebra, Ideals in Boolean algebra, Boolean rings, Boolean functions, Karnaugh maps, Application of Boolean algebra to switching theory.

Unit IV: Graphs, Direct graphs, Undirected graphs, Relations and graphs, Path and circuits, Eulerian and Hamiltonian graphs, Planner graphs, Connected graphs.

TEXT/REFERENCE BOOKS

1. Element of Discrete Mathematics: C. I. Liu, Mcgraw Higher Edu. ,2012.

2. Discrete Mathematical Structures :   H. G. S. Rao, Galgotia Pub. Pvt. Ltd.

3. Lattice and Boolean Algebra: V. K. Khanna, Vikash Pub. House.

4. Discrete Mathematics: R. Johnsonbaugh , Pearson Edu. Ltd., 2014.

Semester-VIII (with Research/Honours)
Major Paper –II: Operations Research (04-Credit)

Unit I: An introduction to operations research, Methodology of O.R., Features of O.R. problems, Different models in O.R., Opportunities and shortcomings of O.R. approach.

Unit II: Dual simplex method, Revised simplex method, Sensitivity analysis.

Unit III: Assignment and Transportation problems.

Unit IV: Theory of games, Integer linear programming.

TEXT/REFERENCE BOOKS

1. Operations Research: KantiSwarup, P.K. Gupta & Man Mohan, S. Chand, 1978.
2. Operations Research: Theory and Applications: J.K. Sharma, Trinity Press, 2016.
3. Operations Research: H.A. Taha, Prentice Hall of India, 2011.
4. Operations Research: R. Bronson,Schaum's Outline Series McGraw Hill, 1982.