SYLLABUS FOR B.SC. (HONOURS)
IN
MATHEMATICS

Under Choice Based Credit System (CBCS)

University of Gour Banga
Malda-732103
West Bengal

B.Sc (Honours) in Mathematics Course Structure under CBCS

Academic Semesters	COURSES					Total Credits	Total Marks
	Discipline Core (DC)	Discipline Specific Elective (DSE)	Generic Elective (GE)	Ability Enhancement Compulsory (AEC)	Skill Enhancement Course (SEC)		
SEM-I	DC01 (6) DC02 (6)		GE01 (6)	AEC1 (2)		20	200
SEM-II	DC03 (6) DC04 (6)		GE02 (6)	AEC2 (2)		20	200
SEM-III	DC05 (6) DC06 (6) DC07 (6)		GE03 (6)			24	200
SEM-IV	DC08 (6) DC09 (6) DC10 (6)		GE04 (6)			24	200
SEM-V	DC11 (6) DC12 (6)	DSE1 (6) DSE2 (6)			SEC01 (2)	26	250
SEM-VI	DC13 (6) DC14 (6)	DSE3 (6) DSE4 (6)			SEC02 (2)	26	250

UNIVERSITY OF GOUR BANGA, MALDA

Draft /Guidelines of UG CBCS Curriculum

Meaning of the Courses and their Abbreviations

A. **Discipline Core (DC) Course:** A course that should compulsorily be studied by a candidate as a core requirement of the Honours and General courses of study.

B. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject. These are of three types:

   (i) **Discipline Specific Elective (DSE) Course:** A course, which may be offered by the main discipline/subject of study.

   (ii) **Dissertation/Project (DP)**: An elective course designed to acquire special/advanced knowledge with an advisory support by a teacher/faculty member. A Project/Dissertation work may be given in lieu of a DSE.

   (iii) **Generic Elective (GE) Course:** An elective course, chosen from an unrelated discipline/subject of study, with an intention to seek exposure beyond discipline/s of choice

C. **The Ability Enhancement (AE) Courses:** These are of two kinds:

(i) **Ability Enhancement Compulsory (AEC) Course**: The course designed for knowledge enhancement consisting of Environmental Studies, English Communication/ Modern Indian Language (**MIL**) communication.

(ii) **Skill Enhancement Course (SEC):** The course designed to provide value-based and/or skill-based knowledge relating to the main discipline.

Semester wise Course Structure under CBCS
For B.A. /B.Sc. / B.Com. (Hons.) Program

Academic Semesters	COURSES					Credits	Marks
	Discipline Core (DC)	Discipline Specific Elective (DSE)	Generic Elective (GE)	Ability Enhancement Compulsory (AEC)	Skill Enhancement (SEC)		
SEM-I	DC1(6) DC2(6)	--	GE-1 (6)	ENVS (2)	--	20	200
SEM-II	DC3(6) DC4(6)	--	GE-2 (6)	Communicative English/Communicative Bengali/MIL* (2)	--	20	200
SEM-III	DC5(6) DC6(6) DC7(6)	--	GE-3 (6)	--	--	24	200
SEM-IV	DC8(6) DC9(6) DC10(6)	--	GE-4 (6)	--	--	24	200
SEM-V	DC11(6) DC12(6)	DSE-1 (6) DSE-2 (6)	--	--	SEC-1 (2)	26	250
SEM-VI	DC13(6) DC14(6)	DSE-3 (6) DSE / DP -4(6)	--	--	SEC-2 (2)	26	250
Total	--	--	--	--	--	140	1300

Notes:

1. Each course is of 50 marks for examination.
2. **DC, DSE and GE:** Each course is of 6 credits for course work per week.
   Non-practical based course: Theory – 5 credits + Tutorial- 1 credit
   Practical based course: Theory – 4 credits + Practical- 2 credits
   Credit = 1 hour duration of teaching (lecture/tutorial) or 2 hour duration of practical period.
3. **AEC and SEC:** Each course is of 2 credits per week.
4. **GE:** An Hons. Student has to study two disciplines (other than Hons. Discipline) as GE having two courses each.
5. **DSE:** A student has to select two DSE courses out of at least three options provided by the main discipline in SEM-V and SEM- VI.
6. **DP:** (Optional) Dissertation/ Project Work in lieu of one DSE-4 in 6th semester

   ***MIL:** Modern Indian Language

Distribution of Credits for B.A/B.Sc./B.Com. Hons. Program

Course type and credit	Number of Courses x Credit (With practical) [Theory:04+Practical:02]		Number of Courses x Credit (Without practical) [Theory:05+Tutorial:01]	
	Theory	Practical	Theory	Tutorial
Discipline Course (DC) (6)	14x4=56	14x2=28	14x5=70	14x1=14
Discipline Specific Elective (DSE) (6)	4x4=16	4x2=8	4x5=20	4x1=4
Generic Elective (GE) (6)	4x4=16	4x2=8	4x5=20	4x1=4
Ability Enhancement Course (AEC) (2)	2x2=4	00	2x2=4	00
Skill Enhancement (SE) (2)	2x2=4	00	2x2=4	00
Courses Credit	96	44	118	22
	Total Credit= 140		Total Credit= 140	

Although the rules and regulations regarding examinations and admissions to UG courses of studies under CBSC are to be decided by the authority of the University through appropriate committees, yet the following may be suggested for consideration.

A. Marks & Question type Distribution for Hons. Courses of Studies

No. of courses	Total credit	Total marks	Division of marks of each course					
			Full marks of each course	Internal Assessment (IA)		End Semester Examination (ESE)		
						Theoretical		Practical
				Attendance 4%	Cont. Evalu. / Test 6%	Descriptive	MCQ	
14 DC	14x6 =84	14x50=700	50 (non practical based)	10		40	nil	nil
			50 (practical based)	10		25	nil	15
04 DSE	04x6=24	4x50=200	50 (non practical based)	10		40	nil	nil
			50 (practical based)	10		25	nil	15
04GE	04x6=24	4x50=200	50 (non practical based)	10		40	nil	nil
			50 (practical based)	10		25	nil	15
02 SE	02x2=04	2x50=100	50	10		40	nil	nil
AEC-1 (ENVS)	01x2=-02	1x50=50	50	10 (Project)		nil	40	nil
AEC-2 (Communicative Bengali/English)	01x2=02	1x50=50	50	10		nil	40	nil
Grand Total	140	1300	--	--		--	--	--

C. Groups of Disciplines/Subjects

A candidate is required to choose not more than one discipline/subject from any of the groups mentioned below.

Group-I	Physics, Zoology, Education, Women Studies
Group-II	History, Mathematics
Group-III	Chemistry, Sociology, Arabic, Sanskrit, Urdu
Group-IV	Botany, Economics, Food & Nutrition
Group-V	Political Science, Defense Studies
Group-VI	Geography, Philosophy, Mass Communication and Journalism
Group-VII	English, Home Science, Physical Education
Group-VIII	Computer Science, Bengali, Hindi

Note: Choice of the discipline will be in compliance with the availability in the particular college

D. Divisions of (Honours and General) disciplines for B.A. /B.Sc. / B.Com degree:

Degree	Streams	Disciplines/ Subjects
B.A.	**Humanities**	Bengali, English, Hindi, Sanskrit, Arabic, Urdu, History, Political Science, Philosophy, Sociology, Economics, Education, Mass Communication & Journalism, Women Studies, Defense Studies, Physical Education
B. Sc	**Science**	Physics, Chemistry, Zoology, Botany, Mathematics, Geography, Physiology, Computer Science, Food and Nutrition, Home Science
B.Com.	**Commerce**	Commerce, Economics, Management Banking

E. Notes regarding B.A. and B.Sc. Degree:

1. **A candidate taking up Honours in B.A. Degree Course shall study: (i)** Honours in any one discipline of the Humanities Division and any two other Generic Elective (GE) disciplines taking at least one from the Humanities Division.

   However, that other things remaining the same, a candidate may take up Honours Course in the B.A. in the discipline like Geography without taking any Generic elective Subject/discipline from the Division of Science.

2. **A candidate taking up General Course of Studies for the B.A. Degree shall study:**
   (i) any three disciplines from the Humanities Division in addition to Language cores - English & MIL.

   Or

   (ii) any two disciplines from the Humanities Division in addition to Language cores - English & MIL and any one from the Science Division.

3. **A candidate taking up Honours Course for B. Sc. Degree shall study:** Honours in any one discipline from the Division of Science and any two other Generic elective (GE) disciplines taking at least one from the Science Division.

4. **A Candidate taking up General Course for the B. Sc. Degree shall study:**
   (i) Any three disciplines from the Science Division.

   Or

   (ii) Any two disciplines from the Science Division and any one discipline from the Humanities Division.

F. Feedback from the Department of Geography:

The Head along with all faculty members of the Department of Geography, UGB, proposed to add the following:

(i) There shall be no B.A. Honours in Geography degree, there shall be only B.Sc. Honours in Geography degree even in case of taking Honours in Geography + two Generic elective disciplines from the Humanities Division.

(ii) But in General Course there shall be B.Sc. as well as B.A. degree with Geography. The case in which taking up Geography + 2 Generic elective disciplines from the Humanities Division is to be entitled as B.A. with Geography and the case when there is Geography + 1 Generic elective from the Science Division or 2 Generic electives from the Science Division is to be called B.Sc. with Geography degree.

Details of Courses of B.Sc. (Honours) in Mathematics under CBCS

Discipline Core Courses (6 credit)

- **MATH-H-DC01** - Calculus & Geometry
- **MATH-H-DC02** - Algebra
- **MATH-H-DC03** - Real Analysis I
- **MATH-H-DC04** - Abstract Algebra
- **MATH-H-DC05** - Real Analysis II
- **MATH-H-DC06** - Linear Algebra
- **MATH-H-DC07** - Multivariate Calculus & Vector Calculus
- **MATH-H-DC08** - Differential Equations
- **MATH-H-DC09** - Mechanics
- **MATH-H-DC10** - Probability & Statistics
- **MATH-H-DC11** - Advanced Analysis on $\mathbb{R}$ & $\mathbb{C}$
- **MATH-H-DC12** - Numerical Methods & C Programming Language
- **MATH-H-DC13** - Linear Programming Problems & Game Theory
- **MATH-H-DC14** - Computer aided Laboratory

Discipline Specific Elective Courses (6 credit)

- **DSE1**
  - **MATH-H-DSE1(1)**- Advanced Algebra
  - **MATH-H-DSE1(2)**- Number Theory
  - **MATH-H-DSE1(3)**- Bio Mathematics
- **DSE2**
  - **MATH-H-DSE2(1)**- Differential Geometry
  - **MATH-H-DSE2(2)**- Fluid Mechanics
  - **MATH-H-DSE2(3)**- Portfolio Optimization
- **DSE3**
  - **MATH-H-DSE3(1)**- Point Set Topology
  - **MATH-H-DSE3(2)**- Theory of Ordinary Differential Equations
  - **MATH-H-DSE3(3)**- Integral Transform
- **DSE4**
  - **MATH-H-DSE4**- Dissertation/Project

Skill Enhancement Courses (2 credit)

- **MATH-H-SEC01** - Discrete Mathematics
- **MATH-H-SEC02** - Problem Solving Techniques in Probability & Statistics

Generic Elective Courses (6 credit)

An Hons. student has to study two disciplines (other than Hons. discipline) as generic elective (GE) having two courses each.

Ability Enhancement Courses (2 credit)

- **AEC1** - Environmental Science
- **AEC2** - Communicative English/Communicative Bengali/Modern Indian Language

Detailed Syllabus

Discipline Core Courses Syllabus

MATH-H-DC01

Calculus & Geometry

Unit-1
Real-valued functions defined on an interval, limit of a function (Cauchy's definition). Algebra of limits. Continuity of a function at a point and in an interval. Acquaintance with the important properties of continuous functions no closed intervals. Hyperbolic functions, higher order derivatives, Leibnitz rule of successive differentiation and its applications to problems of type $e^{ax} + b\sin x$, $e^{ax} + b\cos x$, $(ax+b)^n \sin x$, $(ax+b)^n \cos x$, concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Unit-2
Reduction formulae, derivations and illustrations of reduction formulae of the type integration of $\sin^n x$, $\cos^n x$, $\tan^n x$, $\sec^n x$, $(\log x)^n$, $\sin^n x \sin^m x$, evaluation of definite integrals, integration as the limit of a sum, concept of improper integration, use of Beta and Gamma functions. parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics.

Unit-3
Reflection properties of conics, translation and rotation of axes and second degree equations, reduction and classification of conics using the discriminant, Point of intersection of two intersecting straight lines. Angle between two lines, Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic. Equations of pair of tangents from an external point, chord of contact, Polar equations of straight lines and conics. Equation of chord joining two points. Equations of tangent and normal.

Unit-4
Aquaintance of plane and straight line in 3D may be assumed. Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, reduction and classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Graphical Demonstration (Teaching Aid)

1. Plotting of graphs of function e^{ax+b}, $\log(ax+b)$, $\frac{1}{(ax+b)}$, $\sin(ax+b)$, $\cos(ax+b)$, $|ax+b|$ and to illustrate the effect of a and b on the graph.
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in Cartesian coordinates/polar coordinates.

6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, and hyperbolic paraboloid using Cartesian coordinates.

Reference Books

1. S.L. Loney, The Elements of Coordinate Geometry, Macmillan and Co., 1895.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson, 2005.
3. M.J. Strauss, G.L. Bradley and K.J. Smith, Calculus, 3rd Ed., Pearson Education, 2007.
4. H. Anton, I. Bivens and S. Davis, Calculus, 10th Ed., John Wiley and Sons Inc., 2012.
5. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer, 1989.
6. T.M. Apostol, Calculus (Volumes I & II), John Wiley & Sons, 1967.
7. S. Goldberg, Calculus and mathematical analysis.
8. S. Lang, A First Course in Calculus, Springer 1998.
9. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2nd ed., 2013.
10. R.J.T. Bell, An Elementary Treatise on Coordinate Geometry of Three Dimensions, Macmillan Publishers India Limited, 2000.

MATH-H-DC02

Algebra

Unit-1

Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications. Inequality: The inequality involving AM≥GM≥HM, mth power theorem, Cauchy-Schwartz inequality. Maximum and minimum values of a polynomials.

Unit-2

General properties of equations, Fundamental theorem of classical algebra(statement only) and its application, Transformation of equation, Descarte's rule of signs positive and negative rule, Strum's theorem, Relation between the roots and the coefficients of equations. Symmetric functions. Applications of symmetric function of the roots. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic (Cardon's) and biquadratic (Ferrari's). Properties of the derived functions.

Unit-3

Equivalence relations and partitions, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set. Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Unit-4

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix

equation $Ax = b$, solution sets of linear systems, applications of linear systems, linear independence. Real Quadratic Form involving not more than three variables. Characteristic equation of square matrix of order not more than three determination of Eigen Values and Eigen Vectors. Cayley-Hamilton Theorem.

Reference Books

1. T. Andreescu and D. Andrica, Complex Numbers from A to ... Z, Birkhauser Boston, 2008.
2. D.C. Lay, S.R. Lay and J.J. McDonald, Linear Algebra and its Applications, 5rd Ed., Pearson, 2014.
3. K.B. Dutta, Matrix and linear algebra, Prentice Hall, 2004.
4. K. Hoffman and R. Kunze, Linear algebra, Prentice Hall, 1971.
5. W.S. Burnstine and A.W. Panton, Theory of equations, Nabu Press, 2011.
6. S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, 4th Ed., PHI, 2004.
7. S. Bernard and J.M. Child, Higher Algebra, Macmillan and Co. 1952.

MATH-H-DC03

Real Analysis I

Unit-1

Development of real numbers. The algebraic properties of $\mathbb{R}$, rational and irrational numbers, the order properties of $\mathbb{R}$. Absolute value and the real line, bounded and unbounded sets in $\mathbb{R}$, supremum and infimum, neighbourhood of a point. The completeness property of $\mathbb{R}$, the Archimedean property, density of rational numbers in $\mathbb{R}$, nested intervals property, binary representation of real numbers, uncountability of $\mathbb{R}$. Closed set, open set, closure & interior of a subset of the real line.

Unit-2

Sequences, the limit of a sequence and the notion of convergence, bounded sequences, limit theorems, squeeze theorem, monotone sequences, monotone convergence theorem. Subsequences, monotone subsequence theorem and the Bolzano-Weierstrass theorem, the divergence criterion, limit superior and limit inferior of a sequence, Cauchy sequences, Cauchy's convergence criterion. Infinite series, convergence and divergence of infinite series. Tests for Convergence: Comparison test, root test, ratio test, integral test. Alternating series, absolute and conditional convergence.

Unit-3

Sequential criterion for limits, divergence criteria. Limit theorems, infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorems.

Unit-4

Differentiability of a function at a point and in an interval, Caratheodory's theorem, chain rule, derivative of inverse functions, algebra of differentiable functions. Mean value theorems, Rolle's Theorem, Lagrange's mean value theorem. Applications of mean value theorem to inequalities, relative extremum and approximation of polynomials. The intermediate value property of derivatives, Darboux's theorem. L'Hospital's rule. Taylor's theorem and its application. Expansion of functions.

Graphical Demonstration (Teaching Aid)

1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
5. Cauchy's root test by plotting n-th roots.
6. Ratio test by plotting the ratio of n-th and $(n+1)$-th term.

Reference Books

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., Wiley, 2000.
2. G.G. Bilodeau , P.R. Thie and G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2009.
3. B.S. Thomson, A.M. Bruckner and J.B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
4. S.K. Berberian, A First Course in Real Analysis, Springer, 1998.
5. T.M. Apostol, Mathematical Analysis, Narosa, 2002.
6. R. Courant and F. John, Introduction to Calculus and Analysis, Vol I, Springer, 1999.
7. W. Rudin, Principles of Mathematical Analysis, McGraw Hill, 2017.
8. C.C. Pugh, Real Mathematical Analysis, Springer, 2002.
9. T. Tao, Analysis I, Hindustan Book Agency, 2006
10. S. Goldberg, Calculus and mathematical analysis.
11. H.R. Beyer, Calculus and Analysis, Wiley, 2010.
12. S. Lang, Undergraduate Analysis, Springer, 2nd Ed., 1997.
13. A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.

MATH-H-DC04

Abstract Algebra

Unit-1
Definition and examples of groups, elementary properties of groups. Subgroups and examples of subgroups, centralizer, normalizer, center of a group. Properties of cyclic groups, classification of subgroups of cyclic groups. Permutation group, cycle notation for permutations, properties of permutations, even and odd permutations, alternating group. Cosets, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. Normal subgroup and quotient group.

Unit-2
Group homomorphisms, properties of homomorphisms, properties of isomorphisms. First, Second and Third isomorphism theorems. External direct product of a finite number of groups, Cauchy's theorem for finite abelian groups. Cayley's theorem,

Unit-3
Definition and examples of rings, elementary properties of rings, subrings, integral domains and fields, characteristic of a ring. Ring homomorphisms, properties of ring homomorphisms. First Isomorphism theorem. Isomorphism theorems II and III(statement only), field of quotients. Elementary properties of field. Introduction to polynomial ring.

Unit-4
Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

Reference Books

1. J.B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. J.A. Gallian, Contemporary Abstract Algebra, 8th Ed., Houghton Mifflin, 2012.
4. J.J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer, 1995.
5. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, 1975.
6. D.S. Malik, J.M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, 1996.
7. D.S. Dummit and R.M. Foote, Fundamentals of Abstract Algebra, 3rd Ed., Wiley, 2003.
8. M.K. Sen, S. Ghosh, P. Mukhopadhyay and S.K. Maiti, Topics in Abstract Algebra, 3rd Ed., Universities Press, 2019.

MATH-H-DC05

Real Analysis II

Unit-1
Properties of monotone functions. Functions of bounded variation, total variation, continuous functions of bounded variation. Curves and paths, rectifiable paths and arc length.

Unit-2
Riemann integration: upper and lower sums, upper and lower integral, definition and conditions of integrability. Riemann integrability of monotone and continuous functions, elementary properties of the Riemann integral. Intermediate Value theorems for Integrals. Fundamental theorem of Integral Calculus, change of variables.

Unit-3
Periodic function, Fourier coefficient & Fourier series, convergence, Bessel's inequality, Parseval's inequality, Dirichlet's condition, example of Fourier series. Improper integrals: Range of integration, finite or infinite. Necessary and sufficient condition for convergence of improper integral. Tests of convergence : Comparison and M-test. Absolute and non-absolute convergence and inter-relations. Statement of Abel's and Dirichlet's test for convergence on the integral of a product. Convergence and working knowledge of Beta and Gamma function and their interrelation.

Unit-4
Pointwise and uniform convergence of sequence of functions. Theorems on continuity, differentiability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and differentiability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

Reference Books

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006.
5. T.M. Apostol, Mathematical Analysis, Narosa Publishing House
6. R. Courant and F. John, Introduction to Calculus and Analysis, Vol II, Springer
7. W. Rudin, Principles of Mathematical Analysis, McGraw Hill, 2017.
8. T. Tao, Analysis II, Hindustan Book Agency, 2006
9. S. Shirali and H.L. Vasudeva, Metric Spaces, Springer, 2006.
10. G.G. Bilodeau , P.R. Thie and G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
11. B.S. Thomson, A.M. Bruckner and J.B. Bruckner, Elementary Real Analysis,Prentice Hall, 2001.
12. C.C. Pugh, Real Mathematical Analysis, Springer, 2002.
13. H.R. Beyer, Calculus and Analysis, Wiley, 2010.
14. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.

15. S. Goldberg, Calculus and Mathematical Analysis.

16. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

17. S. Lang, Undergraduate Analysis, 2nd Ed., Springer, 1997.

MATH-H-DC06

Linear Algebra

Unit-1
Definition and examples of vector spaces, subspaces, linear combination of vectors, linear span, linear dependence and independence, bases and dimension.

Unit-2
Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

Unit-3
Linear operator and its eigen value and eigen vectors, characteristic equation, eigenspace, algebraic and geometric multiplicity of eigenvalues. Diagonalization, conditions for diagonalizability. Invariant subspace and Cayley-Hamilton theorem, simple application of Caley-Hamilton Theorem.

Unit-4
Inner products and norms, special emphasis on Euclidean spaces. Orthogonal and orthonormal vectors, Gram-Schmidt orthogonalisation process, orthogonal complements. The adjoint of a linear operator, unitary, orthogonal and normal operators.

Reference Books

1. S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, 4th Ed., PHI, 2004.

2. J.B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

3. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

4. A.R. Rao and P. Bhimasankaram, Linear Algebra, Hindustan Book Agency, 2000.

5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.

6. G. Strang, Linear Algebra and its Applications, Thomson, 2007.

7. S. Kumaresan, Linear Algebra- A Geometric Approach, PHI, 1999.

8. K. Hoffman and R.A. Kunze, Linear Algebra, 2nd Ed., PHI, 1971.

9. S. Axler, Linear Algebra Done Right, Springer, 2014.

10. S.J. Leon, Linear Algebra with Applications, Pearson, 2015.

11. J.S. Golan, Foundations of Linear Algebra, Springer, 1995.

MATH-H-DC07

Multivariate Calculus & Vector Calculus

Unit-1
Functions of several variables, limit and continuity of functions of two or more variables, directioal derivative and partial differentiation, Schwartz's & Young's theorem and Euler's theorem for homogenous function, total differentiability and Jacobian, sufficient condition for differentiability, Mean value theorem, Taylor's theorem, Implicit function theorem(statement only), the gradient, tangent planes. Chain rule for one and two independent parameters. Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

Unit-2
Double integration over rectangular region, double integration over non-rectangular region, changing the order of integration. Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals.

Unit-3
Triple product, introduction to vector fields, operations with vector-valued functions, limits and continuity of vector functions, differentiation of vector valued function, gradient, divergence and curl. Curves and their parameterisation, line integration of vector functions, circulation. Surface and volume integration.

Unit-4
Gauss's theorem, Green's theorem, Stoke's theorem and their simple applications.

Reference Books

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Pearson, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer, 2005.
4. J. Stewart, Multivariable Calculus, Concepts and Contexts, 4nd Ed., Cengage Learning, 2009.
5. T.M. Apostol, Mathematical Analysis, Narosa, 2002.
6. S.R. Ghorpade and B.V. Limaye, A Course in Multivariable Calculus and Analysis, Springer, 2010.
7. R. Courant and F. John, Introduction to Calculus and Analysis (Vol. II), Springer, 1999.
8. W. Rudin, Principles of Mathematical Analysis, McGraw Hill, 2017.
9. J.E. Marsden, and A. Tromba, Vector Calculus, W.H. Freeman, 1996.
10. T. Tao, Analysis II, Hindustan Book Agency, 2006
11. M.R. Speigel, Schaum's outline: Vector Analysis, McGraw Hill, 2017.
12. C.E. Weatherburn, Elementary Vector Analysis: With Application to Geometry and Physics, CBS Ltd., 1926.

MATH-H-DC08

Differential Equations

Unit-1
Exact, linear and Bernoulli's equations. Equations not of first degree, Clairaut's equations, singular solution. Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian and its properties. Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters, Eigenvalue problem.

Unit-2
Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. Equilibrium points, Interpretation of the phase plane.

Unit-3
Power series solution of a differential equation about an ordinary point, solution about a regular singular point. Legendre polynomials, Bessel functions of the first kind and their properties.

Unit-4
Partial differential equations, basic concepts and definitions. First- Order Equations: classification, construction and geometrical interpretation. Method of characteristics for obtaining general solution of quasi linear equations. Canonical forms of first-order linear equations. Solution by Lagrange's and Charpit's method.

Graphical Demonstration (Teaching Aid)

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

Reference Books

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill, 2017.
2. S.L. Ross, Differential Equations, 3rd Ed., Wiley, 2007.
3. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value Problems Computing and Modeling, Pearson, 2005.
4. M.L. Abel and J.P. Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier, 2004.
5. D. Murray, Introductory Course in Differential Equations, Orient Longman, 2003.
6. W.E. Boyce and R.C. Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley, 2009.
7. E.A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications Inc., 1989.

MATH-H-DC09

Mechanics

Unit-1

Coplanar forces in general: Resultant force and resultant couple, Special cases, Varignon's theorem, Necessary and sufficient conditions of equilibrium. Equilibrium equations of the first, second and third kind.

An arbitrary force system in space: Moment of a force about an axis, Varignon's theorem. Resultant force and resultant couple, necessary and sufficient conditions of equilibrium. Equilibrium equations, Reduction to a wrench, Poinsot's central axis, intensity and pitch of a wrench, Invariants of a system of forces. Statically determinate and indeterminate problems.

Equilibrium in the presence of sliding Friction force: Contact force between bodies, Coulomb's laws of static Friction and dynamic friction. The angle and cone of friction, the equilibrium region.

Unit-2

Virtual work: Workless constraints- examples, virtual displacements and virtual work. The principle of virtual work, Deductions of the necessary and sufficient conditions of equilibrium of an arbitrary force system in plane and space, acting on a rigid body.

Stability of equilibrium: Conservative force field, energy test of stability, condition of stability of a perfectly rough heavy body lying on a fixed body. Rocking stones.

Unit-3

Kinematics of a particle: Velocity, acceleration, angular velocity, linear and angular momentum. Relative velocity and acceleration. Expressions for velocity and acceleration in case of rectilinear motion and planar motion in Cartesian and polar coordinates, tangential and normal components. Uniform circular motion.

Newton laws of motion and law of gravitation: Space, time, mass, force, inertial reference frame, principle of equivalence and g. Vector equation of motion. Work, power, kinetic energy, conservative forces-potential energy. Existence of potential energy function.

Energy conservation in a conservative field. Stable equilibrium and small oscillations: Approximate equation of motion for small oscillation. Impulsive forces

Unit-4

Problems in particle dynamics: Rectilinear motion in a given force field - vertical motion under uniform gravity, inverse square field, constrained rectilinear motion, vertical motion under gravity in a resisting medium, simple harmonic motion, Damped and forced oscillations, resonance of an oscillating system, motion of elastic strings and springs.

Planar motion of a particle: Motion of a projectile in a resisting medium under gravity, orbits in a central force field, Stability of nearly circular orbits. Motion under the attractive inverse square law, Kepler's laws on planetary motion. Slightly disturbed orbits, motion of artificial satellites. Constrained motion of a particle on smooth and rough curves. Equations of motion referred to a set of rotating axes.

Reference Books

1. R.D. Gregory, Classical mechanics, Cambridge University Press, 2006.
2. K.R. Symon, Mechanics, Addison Wesley, 1971.
3. M. Lunn, A First Course in Mechanics, Oxford University Press, 1991.
4. J.L. Synge and B.A. Griffith, Principles of Mechanics, Mcgraw Hill, 1949.
5. T.W.B. Kibble, F.H. Berkshire, Classical Mechanics, Imperial College Press, 2004.
6. D.T. Greenwood, Principle of Dynamics, Prentice Hall, 1987.
7. F. Chorlton, Textbook of Dynamics, E. Horwood, 1983.
8. D. Kleppner and R. Kolenkow, Introduction to Mechanics, Mcgraw Hill, 2017.
9. A.P. French, Newtonian Mechanics, Viva Books, 2011.
10. S.P. Timoshenko and D.H. Young, Engineering Mechanics, Schaum Outline Series, 4th Ed., 1964.
11. D. Chernilevski, E. Lavrova and V. Romanov, Mechanics for Engineers, MIR Publishers
12. I.H. Shames and G.K.M. Rao, Engineering Mechanics: Statics and Dynamics, 4th Ed., Pearson, 2009.
13. R.C. Hibbeler and A. Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Pearson, Delhi.
14. S.L. Loney, An Elementary Treatise on the Dynamics of Particle and of Rigid Bodies, Loney Press, 2007.
15. S.L. Loney, An Elementary Treatise on Statics, Cambridge University Press, 2016.
16. R.S. Verma, A Textbook on Statics, Pothishala, 1962.
17. A.S. Ramsey, Dynamics (Part I & II), Cambridge University Press, 1952.

MATH-H-DC10

Probability & Statistics

Unit-1

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

Unit-2

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation

coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

Unit-3
Chebyshevs inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central Limit theorem for independent and identically distributed random variables with finite variance.

Unit-4
Random Samples, Sampling Distributions. Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample problems of normal populations, confidence intervals for proportions, problems. Testing of hypothesis: Null and alternative hypotheses, the critical and acceptance regions, two types of error, Neyman-Pearson Fundamental Lemma, tests for one sample problems for normal populations, tests for proportions, Chi-square goodness of fit test and its applications.

Reference Books

1. I. Miller and M. Miller, John E. Freund's Mathematical Statistics with Applications, 7th Ed., Pearson, 2006.
2. S. Ross, Introduction to Probability Models, 9th Ed., Academic Press, 2007.
3. R.B. Ash, Basic Probability Theory, Dover Publications, 2008.
4. R.V. Hogg, J.W. McKean and A.T. Craig, Introduction to Mathematical Statistics, Pearson, 2007.
5. A.M. Mood, F.A. Graybill and D.C. Boes, Introduction to the Theory of Statistics, 3rd Ed., McGraw Hill, 2007.
6. A. Gupta, Groundwork of Mathematical Probability and Statistics, Academic Publisher, 2015.
7. W. Feller, An Introduction to Probability Theory and its Applications, Wiley, 1968.
8. A.P. Baisnab and M. Jas, Elements of Probability and Statistics, McGraw Hill, 1993.
9. V.K. Rohatgi, A.K.Md.E. Saleh, An Introduction to Probability and Statistics, Wiley, 2008.

MATH-H-DC11

Advanced Analysis on $\mathbb{R}$ & $\mathbb{C}$

Unit-1
Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, Closed set, closure, subspaces, dense sets, separable spaces.

Unit-2
Sequences and their convergence in matric spaces, Cauchy sequences. Complete Matric Spaces,

Cantor's theorem. Continuous mappings, sequential criterion and other characterizations of continuity, uniform continuity. Connectedness and compactness of a metric space.

Unit-3
Limits and continuity of the complex functions. Complex differentiation and the Cauchy-Riemann equations, analytic functions, examples of analytic functions, elementary properties of analytic functions, harmonic function, evaluation of the harmonic conjugate. Complex power series and radius of convergence, complex exponential function, trigonometric functions, hyperbolic functions, complex logarithm and analytic branch of logarithm. Introduction to conformal mapping.

Unit-4
Complex valued function defined on real intervals, curves and paths in the complex plane, parameterization of curves, contour and its elementary properties. Complex line integrals, Cauchy- Goursat theorem, Cauchy's theorem and its simple application, Cauchy's integral formula. Power series representation of complex functions, Taylor series representation, Laurent series representation.

Reference Books

1. S. Shirali and H.L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
2. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
3. M.Ó Searcoid, Metric Spaces, Springer, 2007.
4. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2004.
5. J.E. Marsden and M.J. Hoffman, Basic Complex Analysis, W.H. Freeman, 1998.
6. J.W. Brown and R.V. Churchill, Complex Variables and Applications, 8th Ed., McGraw Hill, 2009.
7. J. Bak and D.J. Newman, Complex Analysis (Undergraduate Texts in Mathematics), 2nd Ed., Springer, 1997.
8. S. Ponnusamy, Foundations of Complex Analysis, Narosa, 2011.
9. E.M. Stein and R. Shakrachi, Complex Analysis, Princeton University Press, 2003.
10. J.B. Conway, Functions of one Complex variable, Narosa, 1996.
11. D. Sarason, Complex Function Theory, Hindustan Book Agency, 2008.
12. V. Karunakaran, Complex Analysis, Alpha Science, 2005.
13. T.W. Gamelin, Complex Analysis, Springer, 2001.
14. A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
15. K.A. Ross, Elementary Analysis: The Theory of Calculus (Undergraduate Texts in Mathematics), Springer, 2013.
16. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., Wiley, 2002.
17. C.G. Denlinger, Elements of Real Analysis, Jones & Bartlett, 2011.

18. S. Goldberg, Calculus and Mathematical Analysis.

19. T.M. Apostol, Calculus (Vol. I & II), Wiley, 2007

MATH-H-DC12

Numerical Methods & C Programming Language

Unit-1
Errors: Relative, Absolute, Round off, Truncation, Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Convergence of these methods.

Unit-2
System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU Decomposition. Finite difference operators. Interpolation: Newton's and Lagrange methods. Error bounds. Central difference interpolation. Numerical differentiation.

Unit-3
Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's 1/3rd rule, Gauss quadrature formula. The algebraic eigenvalue problem: Power method. Approximation: Least square polynomial approximation.

Ordinary Differential Equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

Unit-4
Overview of the C-Programming Languages, Data Type, Constants and Variables, Input and Output, Operators and Expressions, if-else Statement, switch Statement, for Loop, while Loop, do-while Loop, break and continue, functions, array and simple problems.

Reference Books

1. K.E. Atkinson, An Introduction to Numerical Analysis, John Wiley and Sons, 1978.

2. B.W. Kernighan and D. Ritchie, The C Programming Language, Prentice Hall, 1988.

3. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

4. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, 2007.

5. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.

6. U.M. Ascher and C. Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.

7. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
8. J.B. Scarborough, Numerical Mathematical Analysis, Oxford and IBH, 2005.
9. H. Schildt, The Complete Reference: C, McGraw Hill, 2017.
10. G. David, Head First C, Shroff, 2012.
11. S. Prata, C Primer Plus, Sams, 2004.
12. C. Xavier, C Language and Numerical Methods, New Age International, 2007.
13. B. Gottfried, Programming with C, McGraw Hill, 2017.
14. E. Balaguruswamy, Programming in ANSI C, McGraw Hill, 2017.
15. F.J. Scheid, Computers and Programming, McGraw-Hill, 1982.
16. T. Jeyapoovan, A First Course in Programming With C, Vikas Publication House, 2004.
17. Y. Kanetkar, Let Us C, BPB Publications, 2016.

MATH-H-DC13

Linear Programming Problems & Game Theory

Unit-1
Linear programming modeling, Optimal solutions and graphical interpretation of optimality. Notion of convex set, convex function, their properties and applications in context of LPP. Preliminary definitions (like convex combination, extreme point etc.). Optimal hyper-plane and existence of optimal solution of LPP. Basic feasible solutions: algebraic interpretation of extreme point. Relationship between extreme points and corresponding BFS. Adjacent extreme points and corresponding BFS along with examples. Fundamental theorem of LPP and its illustration through examples.

Unit-2
LPP in canonical form to get the initial BFS and method of improving current BFS. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison.

Unit-3
Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

Unit-4
Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of

games.

Reference Books

1. M.S. Bazaraa, J.J. Jarvis and H.D. Sherali, Linear Programming and Network Flows, 2nd Ed., Wiley, 2004.
2. P.K. Dutta, Strategies and Games: Theory and Practice, MIT Press, 1999.
3. L.F. Fernandez and H.S. Bierman, Game Theory with Economic Applications, Addison Wesley, 1998.
4. R.D. Gibbons, Game Theory for Applied Economists, Princeton University Press, 1992.
5. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., McGraw Hill, 2009.
6. H.A. Taha, Operations Research: An Introduction, 8th Ed., Prentice Hall India, 2006.
7. G. Hadley, Linear Programming, Narosa, 2002.

MATH-H-DC14

Computer aided Laboratory

List of practical (By using C in LINUX)

1. Solution of transcendental and algebraic equations by
   - Bisection method
   - Newton Raphson method.
   - Fixed point method.
   - Regula Falsi method.
2. Solution of system of linear equations
   - LU decomposition method
   - Gaussian elimination method
   - Gauss-Jacobi method
   - Gauss-Seidel method
3. Interpolation
   - Lagrange Interpolation
   - Newton Interpolation
4. Numerical Integration
   - Trapezoidal Rule
   - Simpson's one third rule
   - Weddle's Rule

- Gauss Quadrature

5. Method of finding Eigenvalue by Power method
6. Fitting a Polynomial Function
7. Solution of ordinary differential equations
    - Euler method
    - Modified Euler method
    - Runge Kutta method
8. Programming in probability and statistics
    - Probability by using Empirical Definition
    - Mean
    - Median
    - Mode
    - Standard deviation
    - Coefficient of correlation
9. Matrices
    - Determinants
    - Transpose
    - Product
    - Addition/Substration
    - Rank
    - Inverse

Discipline Specific Elective Courses Syllabus

MATH-H-DSE1(1)

Advanced Algebra

Unit-1
Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

Unit-2
Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.

Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions. Generalized Cayleys theorem. Index theorem.

Unit-3
Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups, Sylow's theorems and consequences, Cauchys theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests.

Unit-4
Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in $\mathbb{Z}[x]$. Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclidean domains.

Reference Books

1. J.B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. J.A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1999.
4. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
5. G. Strang, Linear Algebra and its Applications, Thomson, 2007.
6. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
7. K. Hoffman and R.A. Kunze, Linear Algebra, 2nd Ed., Prentice Hall of India, 1971.
8. S.H. Friedberg, A.L. Insel and L.E. Spence, Linear Algebra, Prentice Hall of India, 2004
9. D.S. Dummit and R.M. Foote, Abstract Algebra, 3rd Ed., Wiley & Sons, 2004.
10. J.R. Durbin, Modern Algebra, Wiley & Sons, 2000.
11. D. A. R. Wallace, Groups, Rings and Fields, Springer, 1998

12. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, 1996.

13. I.N. Herstein, Topics in Algebra, Wiley, India, 1975.

MATH-H-DSE1(2)

Number Theory

Unit-1
Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

Unit-2
Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues. some properties of Eulers phi-function.

Unit-3
Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli.

Unit-4
Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem.

Reference Books

1. D.M. Burton, Elementary Number Theory, 6th Ed., McGraw Hill, 2007.

2. N. Robinns, Beginning Number Theory, 2nd Ed., Narosa, 2007.

3. G.A. Jones and J.M. Jones, Elementary Number Theory, Springer, 1998.

MATH-H-DSE1(3)

Bio Mathematics

Unit-1
Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC).

Unit-2
Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.

Unit-3
Spatial Models: One species model with diffusion, Two species model with diffusion. Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population.

Unit-4
Discrete Models: Overview of difference equations, steady state solution and linear stability analysis. Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

Graphical Demonstration (Teaching Aid)

1. Growth model (exponential case only).
2. Decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration).
4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting).
6. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
7. Epidemic model of infuenza (basic epidemic model, contagious for life, disease with carriers).
8. Battle model (basic battle model, jungle warfare, long range weapons).

Reference Books

1. L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
2. J. D. Murray, Mathematical Biology, Springer, 1993.
3. Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.
5. M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

MATH-H-DSE2(1)

Differential Geometry

Unit-1
Tensor Analysis: Different transformation laws, Properties of tensors, Metric tensor, Riemannian space, Covariant Differentiation, Einstein space.

Unit-2
Theory of Space Curves: Space curves. Planer curves, Curvature, torsion and Serret-Frenet formula. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

Unit-3
Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Eulers theorem. Rodrigue's formula. Conjugate and Asymptotic lines.

Unit-4
Developables: Developable associated with space curves and curves on surfaces, Minimal surfaces. Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem.

Reference Books

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
3. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
4. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
5. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
6. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003.
7. E. Kreyszig, Differential Geometry, Dover Publications, 1991.
8. S. Kumaresan, A Course in Differential Geometry and Lie Groups, Hindustan Book Agency, 2002.

MATH-H-DSE2(2)

Fluid Mechanics

Unit-1
Perfect fluid. Pressure at a point. Pressure of heavy fluid. Pressure at any point of a fluid at rest is the same in every directions. Conditions of equilibrium for homogeneous, heterogeneous, and elastic fluid. Lines of force. Surfaces of equal pressure and density. Pressure gradient, pressure function and equation of equilibrium. Homogeneous fluid at rest under gravity.

Unit-2
Definition of center of pressure. Formula for the depth of the center of pressure of a plane area. Position of center of pressure. Thrusts on plane and curved surfaces. Rotating fluid. Pressure at any point and surfaces of equipressure when a mass of homogeneous fluid contained in a vessel revolves uniformly about a vertical axis. Floating bodies. Stability of equilibrium of floating bodies.

Unit-3
Kinematics of Fluid: Scalar and Vector Field, flow field, Description of Fluid Motion. Lagrangian method, Eulerian method, Relation between Eulerian and Lagrangian method, Variation of flow parameters in time and space. Steady and unsteady flow, uniform and non-uniform flow. Material derivative and acceleration: temporal derivative, convective derivative.

Unit-4
Conservation Equation: Control mass system, control volume system, Isolated system. Conservation of Mass-The Continuity equation: Differential form and vector form, integral form. Conservation of Momentum: Momentum theorem, Reynolds transport theorem. Conservation of energy.

Reference Books

1. G.K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press, 1967.
2. F. Chorlton, Textbook of Fluid Dynamics, Van Nostrand Co., 1967.
3. F.M. White, Fluid Mechanics, McGraw Hill, 2003.
4. P.K. Kundu and I.M. Cohen, Fluid Mechanics, 4th Rev. Ed., Academic Press, 2008.
5. G. Falkovich, Fluid Mechanics: A short course for physicists, Cambridge University Press, 2011.
6. I.G. Currie, Fundamental Mechanics of Fluids, McGraw Hill, 1974.
7. B. Massey and J.W. Smith, Mechanics of Fluids, 8th Ed., Taylor & Francis, 2005.

MATH-H-DSE2(3)

Portfolio Optimization

Unit-1
Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.

Unit-2
Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory.

Unit-3
Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line.

Unit-4
Index tracking optimization models. Portfolio performance evaluation measures.

Reference Books

1. F. K. Reilly and K.C. Brown, Investment Analysis and Portfolio Management, 10th Ed., South Western Publishers, 2011.
2. H.M. Markowitz, Mean-Variance Analysis in Portfolio Choice and Capital Markets, Blackwell, 1987.
3. M.J. Best, Portfolio Optimization, Chapman and Hall, CRC Press, 2010.
4. D.G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2013.

MATH-H-DSE3(1)

Point Set Topology

Unit-1
Countable and Uncountable Sets, Schroeder-Bernstein Theorem, Cantors Theorem. Cardinal Numbers and Cardinal Arithmetic. Continuum Hypothesis, Zorns Lemma, Axiom of Choice. Well-Ordered Sets, Hausdorffs Maximal Principle. Ordinal Numbers.

Unit-2
Topological spaces, Basis and Subbasis for a topology, subspace Topology, Interior Points, Limit Points, Derived Set, Boundary of a set, Closed Sets, Closure and Interior of a set.

Unit-3
Continuous Functions, Open maps, Closed maps and Homeomorphisms. Product Topology, Quotient Topology, Metric Topology, Baire Category Theorem.

Unit-4
Connected and Path Connected Spaces, Connected Sets in $\mathbb{R}$, Components and Path Components, Local Connectedness. Compact Spaces, Compact Sets in $\mathbb{R}$. Compactness in Metric Spaces. Totally Bounded Spaces, Ascoli-Arzela Theorem, The Lebesgue Number Lemma. Local Compactness.

Reference Books

1. J.R. Munkres, Topology: A First Course, Prentice Hall of India, 2000.

2. J. Dugundji, Topology, Allyn and Bacon, 1966.

3. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

4. K.D. Joshi, Introduction to General Topology,New Age International Private Limited, 2017.

5. J.L. Kelley, General Topology, Springer, 1975.

6. J. Hocking and G. Young, Topology, Dover Publications, 1988.

7. L.A. Steen and J.A. Seebach, Counter Examples in Topology, Dover Publications, 1995.

MATH-H-DSE3(2)

Theory of Ordinary Differential Equations

Unit-1
Fundamental theorem for existence and uniqueness, Gronwall's inequality, Dependence on initial conditions and parameters, maximal interval of existence, Global existence of solutions, vector fields and flows, Topological conjugacy and equivalence.

Unit-2
Linear flows on $\mathbb{R}_n$, The matrix exponential, linear first order autonomous systems, Jordan canonical forms, invariant subspaces, stability theory, classification of linear flows, fundamental matrix solution, non-homogeneous linear systems.

Unit-3
Periodic linear systems and Floquet theory. α & ω Limit sets of an orbit, attractors, periodic orbits and limit cycles.

Unit-4
Local structure of critical points (the local stable manifold theorem, the Hartman-Grobman theorem, the center manifold theorem), the normal form theory, Lyapunov function, local structure of periodic orbits (Poincaré map and Floquet theory), the Poincaré-Benedixson theorem. Benedixson's criterion, Liénard systems.

Reference Books

1. E.A. Coddington and R. Carlson, Linear Ordinary Differential Equations, SIAM, 1987.

2. C. Chicone, Ordinary Differential Equations with Applications, Springer, 2006.

3. L.D. Perko, Differential Equations and Dynamical Systems, Springer, 2001.

4. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw Hill, 2017.

MATH-H-DSE3(3)

Integral Transform

Unit-1
Fourier integral theorem, Definition of Fourier Transforms, Algebraic and analytic properties of Fourier Transform, Fourier sine and cosine Transforms, Fourier Transforms of derivatives, Fourier Transforms of some useful functions, Inversion formula of Fourier Transforms, Convolution Theorem, Parseval's relation.

Unit-2
Definition and properties of Laplace transforms, Sufficient conditions for the existence of Laplace Transform, Laplace Transform of some elementary functions, Laplace Transforms of the derivatives, Initial and final value theorems, Convolution theorems, Inverse of Laplace Transform.

Unit-3
Definition, Examples, Basic Operational Properties of Z-transformation. Inverse Z-Transform.

Unit-4
Applications of Fourier transforms in solving ordinary and partial differential equations. Application to Ordinary and Partial differential equations. Applications of Z-Transforms to Finite Difference Equations

Reference Books

1. I.N. Sneddon, Fourier Transforms, McGraw Hill, 1995.
2. I.N. Sneddon, Use of Integral Transforms, McGraw Hill, 1972.
3. L.C. Andrews and B. Shivamoggi, Integral Transforms for Engineers, SPIE, 1999.
4. L. Debnath and D. Bhatta, Integral Transforms and Their Applications, CRC Press, 2007.

Skill Enhancement Course Syllabus

MATH-H-SEC01

Discrete Mathematics

Unit-1
Definition of undirected graphs, Using of graphs to solve different puzzles and problems. Multigraphs. Walks, Trails, Paths, Circuits and cycles, Eulerian circuits and paths. Eulerian graphs, example of Eulerian graphs. Hamiltonian cycles and Hamiltonian graphs. Weighted graphs and Travelling salespersons Problem. Dijkstra's algorithm to find shortest path. Definition of Trees and their elementary properties. Definition of Planar graphs, Kuratowski's graphs. Partial Order relations and lattices, Chains and antichains. Pigeon hole Principle.

Unit-2
Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Unit-3
Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set. Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation. Partial ordering relations, n-ary relations.

Unit-4
Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Logic gates, switching circuits and applications of switching circuits.

Reference Books

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
2. P.R. Halmos, Naive Set Theory, Springer, 1974.
3. E. Kamke, Theory of Sets, Dover Publishers, 1950.
4. K.A. Ross and C.R. Wright, Discrete Mathematics, Prentice Hall, 2002.

MATH-H-SEC02

Problem Solving Techniques in Probability & Statistics

Unit-1

1. Application problems based on Classical Definition of Probability.
2. Application problems based on Bayes' Theorem.
3. Fitting of binomial distributions for n and $p = q = \frac{1}{2}$.
4. Fitting of binomial distributions for given n and p.
5. Fitting of binomial distributions after computing mean and variance.
6. Fitting of Poisson distributions for given value of lambda.
7. Fitting of Poisson distributions after computing mean.

Unit-2

1. Fitting of negative binomial distribution.
2. Fitting of suitable distribution.
3. Application problems based on binomial distribution.
4. Application problems based on Poisson distribution.
5. Application problems based on negative binomial distribution.

Unit-3

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis

Unit-4

1. Fitting of polynomials, exponential curves
2. Karl Pearson correlation coefficient
3. Partial and multiple correlations
4. Spearman rank correlation with and without ties.
5. Correlation coefficient for a bivariate frequency distribution
6. Lines of regression, angle between lines and estimated values of variables.
7. Checking consistency of data and finding association among attributes.