Department of Mathematics
List of Courses for the Minor in Mathematics Program
Minor in Mathematics

Program Core (PC)		Program Elective (PE)	
Category	Credit	Category	Credit
Departmental Core (DC)	8	Departmental Electives (DE)	8
Engineering Science (ES)	0	Humanities and Management (HM)	0
Humanities (HU)	0	Open Courses (OC)	0
Total	8	Total	8
Grand Total PC+PE			16

Mathematics Minor Scheme:

Sr. No.	Course Code	Course Title	Type DC /DE	Structure L-T-P	Credits
1	MALXXX	Advanced Calculus	DC	3-1-0	4
2	MALXXX	Differential Equations	DC	3-1-0	4
3	MALXXX	Elective 1	DE	3-1-0	4
4	MALXXX	Elective 2	DE	3-1-0	4
	Total credits				16

For Elective 1:

1	Linear Algebra
2	Computational Methods for Differential Equations
*Students who have undergone the courses MAL206 or MAL 210 cannot opt for the Linear Algebra course.	

For Elective 2:

1	Modern Algebra
2	Applied Statistics and Stochastic Processes

1. The Department of Mathematics will offer a Minor in Mathematics to the B.tech students of other disciplines of the Institute.
2. Students will opt for Minor in Mathematics at the end of their second semester.

Advanced Calculus

Course Code & Course Title:	MAL XXX -Advanced Calculus		
Course Type:	DC		
Name of the programme(s):	Minor in Mathematics		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	Nil		

1.	**Course Objective:**

This advanced calculus course aims to provide students with a deep understanding of fundamental concepts and techniques in calculus, extending beyond basic calculus topics covered in MAL 101 and MAL 102.

2.	**Course Outcomes (Min. 3 & Max. 5):** After completing this course students will be able to:
CO1	Grasp the fundamentals of metric spaces, convergence in metric spaces, limits and continuity in metric spaces, compact sets, perfect sets, connected sets
CO2	Analyze the convergence properties of sequence and series of functions, uniform and point wise convergence, convergence of power series and their properties
CO3	Understand the concepts of Multivariate Calculus: Differentiability in R^n, simplices and singular chains and Stokes' theorem for integral of differential forms on chains on R^n

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Metric Spaces, Open and Closed sets, Convergence of Sequences in Metric Spaces, Functions on metric spaces, Limit, continuity and uniform continuity on metric spaces, Connected set and path connected, Complete Metric Spaces, Baire Category theorem, Banach contraction principle and some of its applications, Heine Borel theorem, total boundedness, characterization of compactness for arbitrary metric spaces.		CO1	5
Sequences and series of functions, Weierstrass M-test, uniform convergence and its relation to continuity, differentiation and integration, equicontinuity, Arzela-Ascoli theorem, Weierstrass approximation theorem.		CO2	4

Differentiability in R^n, Directional derivatives, Chain Rule, Inverse function theorem, Implicit function theorem, Riemann integral of real-valued functions on R^n, Fubini's theorem, Partition of unity, change of variables, Integration on Chains, Differential Forms on R^n, simplices and singular chains, Stokes' theorem for integral of differential forms on chains (general version) on R^n, closed and exact forms, Poincaré lemma. Classical Green's theorem, divergence theorem and Stokes' formula as applications of the general form of Stokes' theorem.	CO3	5

4.	**Text books**

i) T. M. Apostol, Mathematical Analysis, Addison-Wesley Publishing Co., 1957.

ii) R. G. Bartle, The Elements of Real Analysis, 2nd Ed., J. Wiley, NY, London, 1964.

iii) W. Fleming, Functions of Several Variables, Second Edition, Springer-Verlag, 1977.

iv) S. R. Ghorpade and B. V. Limaye, A Course in Multivariate Calculus and Analysis, Springer, 2009.

v) E. Hewitt and K. Stromberg, Real and Abstract Analysis, John Wiley, N.Y., 1965.

vi) W. Rudin, Principles of Mathematical Analysis, McGraw Hill Book Co., 1976.

5.	**Reference Book(s) and Other Required Material**

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO2	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO3	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Differential Equations

Course Code & Course Title:	MAL XXX - Differential Equations		
Course Type:	DC		
Name of the programme(s):	Minor in Mathematics		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this course is to introduce power series method for solving differential equations with variable coefficients, Matrix method for system of equations, Green function technique to solve BVPs for ODEs, Eigenvalue problems and various methods for first and –higher order PDEs.

2.	**Course Outcomes (Min. 3 & Max. 5):** Upon successful completion of the course, students will be able to
CO1	Find power series solution of second order differential equations with variable coefficients
CO2	Apply matrix method for solving system of equations and find fundamental matrix of system of ODEs
CO3	Solve the BVPs by means of Green's function technique and eigenvalue problems
CO4	Solve linear first - and higher order PDEs
CO5	Find Canonical forms of first - and second order linear equations

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Power series solutions of second-order linear differential equations, Frobenius method, Legendre, Chebyshev and Bessel differential equations,		CO1	4
Existence-Uniqueness theorem for system of equations (statement only), Homogeneous systems of linear differential equations, Fundamental matrix, Matrix method, Non-homogeneous linear systems.		CO2	2
Boundary Value Problems: Green's function technique, Sturm-Liouville problem, Eigenvalue problems, Sturm's fundamental comparison theorem.		CO3	3

Linear partial differential equations of first order, Lagrange's method, Charpit's method, Method of characteristics, Cauchy problem, Non-homogeneous higher-order partial differential equations with constant coefficients, Equations with variable coefficients reducible to linear PDEs with constant coefficients.	CO4	3
Canonical forms of first and second-order linear equations.	CO5	2

4.	**Text books**

i) E. A. Coddington: An Introduction to Ordinary Differential Equations, Prentice Hall of India, 2009.

ii) S.L. Ross, Differential Equations, Wiley, India Pvt. Ltd., 2011.

iii) S.G. Deo,V. Raghavendra, R. Kar, V. Lakshmikantham: Textbook of Ordinary Differential Equations, Tata McGraw Hill Pub. Co., New Delhi, 2017.

iv) G. Birkhoff, G-C Rota, Ordinary Differential Equations, Wiley, 2016.

v) I.N. Sneddon: Elements of Partial Differential Equations, McGraw Hill, New York, 1957.

vi) E. C. Zachmanoglou , D. W. Thoe, Introduction to Partial Differential Equations with Applications, Dover Publications, Inc., New York, 1987.

5.	**Reference Book(s) and Other Required Material**

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO2	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO3	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO4	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO5	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Linear Algebra

Course Code & Course Title:	MAL XXX - Linear Algebra		
Course Type:	DE		
Name of the programme(s):	Minor in Mathematics		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the importance of Linear Algebra to improve ability to think logically, analytically, and abstractly.

2.	**Course Outcomes (Min. 3 & Max. 5):** After completing this course students will be able to
CO1	Understand basic concepts of vector spaces, subspaces, bases etc.
CO2	Understand linear transformations on Finite dimensional vector spaces, their properties and related results
CO3	Work out applications related to linear transformation and eigenvalues
CO4	Understand inner product structure on Inner product space and norms structure on normed linear spaces
CO5	Know properties and related results of Unitary, Normal and self-adjoint operators

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Vector space and Linear transformations: Vector spaces, Subspaces, Bases and dimension, Linear transformations, Isomorphism, Representation of linear transformation by matrices, Rank-nullity theorem, Linear functional, Double dual, Transpose of a linear transformation.		CO1, CO2	5
Elementary Canonical Forms, Rational and Jordan Form: Characteristic values and characteristic vectors of linear transformations, annihilating polynomials, Invariant subspace, minimal polynomial of a linear transformation, Cayley Hamilton theorem, diagonalizability,		CO2, CO3	5

triangulation, The primary decomposition and the Rational form, The Jordan form.		
Inner Product Spaces: Inner products, Inner product spaces, Adjoints, Unitary operator, Normal operator, Orthonormal basis, Gram-Schmidt Theorem, Bilinear forms.	CO4, CO5	4

4.	**Text books**

i) K. Hoffman and R. Kunze, Linear Algebra, Pearson Education (India), 2003.

ii) M. Artin: Algebra, Prentice Hall of India, 2005.

iii) I. N Herstein: Topics in Algebra, 2 nd Edition, John-Wiley, 1999.

iv) S. Lang: Linear Algebra, Springer Undergraduate Texts in Mathematics, 1989.

v) S. Kumeresan: Linear Algebra: A Geometric Approach, Prentice Hall of India, 2004.

5.	**Reference Book(s) and Other Required Material**

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO2	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO3	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO4	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO5	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Computational Methods for Differential Equations

Course Code & Course Title:	MAL XXX - Computational Methods for Differential Equations		
Course Type:	DE		
Name of the programme(s):	Minor in Mathematics		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of the course is to introduce various numerical techniques to solve boundary value problems in ODEs and PDEs. Further, theoretical results on consistency, stability and convergence for these numerical methods will be investigated.

2.	**Course Outcomes (Min. 3 & Max. 5):** Upon successful completion of the course, students will be able to
CO1	Solve linear and nonlinear boundary value problems in ordinary differential equations
CO2	Understand different types of numerical methods for solving parabolic, hyperbolic and elliptic partial differential equations
CO3	Establish theoretical results on consistency, stability and convergence analysis of various numerical schemes
CO4	Develop programs (using MATLAB or any suitable language) for implementation of various numerical methods for the solutions of boundary value problems in ODEs and PDEs

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Review of vector and matrix norms, linear systems solvers (Gauss Seidel, SoR, and conjugate gradient methods, tri-diagonal solvers), non-linear system solvers (Newton's method)		CO3	2
Computer arithmetic: Computer representation of numbers, round off errors, error propagation in computer arithmetic, addition and multiplication of floating-point numbers.		CO3	2
Second - and fourth order compact finite difference methods for linear and non-linear boundary value problems in ordinary differential equations		CO1, CO3	4

with explicit and implicit boundary conditions, Error analysis, Stability analysis, Convergence analysis.		
Explicit and implicit finite difference schemes for parabolic equations and hyperbolic equations,	CO2, CO3	3
ADI methods. Finite difference methods for two dimensional Poisson's equations with Dirichlet, Neumann and mixed boundary conditions.	CO4	3

4.	**Text books**

i) Numerical Analysis: Mathematics of Scientific Computing by David Kincaid and Ward Cheney, AMS, 2009.

ii) Computation methods for Partial differential equations by M.K. Jain, S.R.K Iyengar, R.K Jain, New Age International Publishers, 2016.

iii) Finite Difference methods for ordinary and Partial differential equations, Randall J. LeVeque, SIAM, 2007.

iv) G.D.Smith: Numerical Solution of Partial Differential Equations, Oxford University Press, 1985.

5.	**Reference Book(s) and Other Required Material**

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO2	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO3	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO4	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Applied Statistics and Stochastic Processes

Course Code & Course Title:	MAL XXX - Applied Statistics and Stochastic Processes		
Course Type:	DE		
Name of the programme(s):	Minor in Mathematics		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this course is to expose student to understand the importance of probability theory and stochastic processes along with real life applicability.

2.	**Course Outcomes (Min. 3 & Max. 5):** After completing this course students will
CO1	Understand the concept of probability and their applications in real life, engineering and industrial problems
CO2	Learn the transformations of random variables and significant special discrete and continuous distribution
CO3	Be able to use the concept of stochastic processes and their applications
CO4	Apply the branching and renewal process in engineering problems

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Model verification: Bayesian parametric models, Conjugate prior, Bayesian estimators, Type-I and Type-II errors, Chi-Squared goodness-of-fit test with known and estimated parameters, Kolmogorov–Smirnov test		CO1	3
Regression and Correlation: Simple and multiple linear regression, Least squares method of estimation, Properties of least-square estimators, Confidence intervals for regression coefficients, Normal regression and correlation analysis		CO2	3
Convergence in probability, Convergence in distribution, Mean square convergence, Almost sure convergence, Weak and strong law of large numbers, Central limit theorem Basics of random processes along with		CO3	4

examples, Discrete and Continuous-time Markov Chains (MCs), Chapman-Kolmogorov equation, Poisson and compound Poisson process, birth-death processes, Transition probability matrix, First passage time Random telegraph signal, Digital modulation using phase-shift, Random walk and gambler's ruin problem, Brownian motion, Wiener process as a limit of random walk		
Galton-Watson branching processes, probability generating function, mean and variance, probability of extinction, Renewal function and its properties, cost/rewards associated with renewals, Markov renewal and regenerative processes.	CO4	2

4.	**Text books**

i) Karlin.S and Taylor. H., 1975. A First Course in Stochastic Processes. Academic Press, New York.

ii) Stark, H. and Woods, J. 2002. Probability and Random Processes with Applications to Signal Processing. Prentice Hall, New Jersey.

iii) Miller, I. and Freund, J. 2005. Probability and Statistics for Engineers, Person education.

iv) Papoulis, A. and Pillai, U. 2002. Probability, Random Variables, and Stochastic Processes, McGraHill.

v) Soong, T. T. 2004. Fundamentals of Probability and Statistics for Engineers, John Wilely and Sons Ltd, New York.

5.	**Reference Book(s) and Other Required Material**

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO2	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO3	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO4	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Modern Algebra

Course Code & Course Title:	MAL XXX - Modern Algebra		
Course Type:	DE		
Name of the programme(s):	Minor in Mathematics		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

i) To understand the basic notions of groups with various examples.

ii) To introduce the concepts of rings and polynomials.

iii) To understand the basic concepts in ring and field theory.

iv) To give an integrated approach to abstract algebra, and provide a firm basis for further reading and study in the subject.

2.	**Course Outcomes (Min. 3 & Max. 5):** Upon successful completion of the course, students will be able to
CO1	Understand several important concepts in abstract algebra, including group, ring, field, homomorphism, isomorphism, and quotient structure
CO2	To understand several concepts in abstract algebra, like homomorphism, isomorphism etc.
CO3	Able to apply some of these concepts to real world problems

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Formal properties of integers, equivalence relations, division algorithm for integers, primes, unique factorization, congruences, Chinese remainder theorem, Euler function, Fundamental Theorem of Algebra. Groups, subgroups, factor groups, Lagrange's Theorem		C01	2
homomorphisms, normal subgroups. Quotients of groups, Basic examples of groups: symmetric groups, matrix groups, group of rigid motions of the plane and finite groups of motions. Cyclic groups, generators and relations, Cayley's Theorem, group actions, Sylow's Theorems. Direct products, Structure Theorem for finite abelian groups.		CO1, CO2	3

Rings, ideals, prime and maximal ideals, rings of fractions. Euclidean Domains, Principal Ideal Domains and Unique Factorization Domains. Polynomial rings over UFD's	CO3	3
Fields, finite fields, field extensions, splitting field.	CO3	2

4.	**Text books**

i) M. Artin, Algebra, Prentice Hall of India, 1994.

ii) J. A. Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa, 1999.

iii) D. S. Dummit and R. M. Foot, Abstract Algebra, John Wiley & Sons, Inc., II Edition, 1999.

iv) S. Lang, Algebra, III edition, Springer, 2004.

5.	**Reference Book(s) and Other Required Material**

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO2	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---
CO3	3	2	1	---	---	---	---	---	---	---	---	2	---	---	---

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**