DEPARTMENT OF MATHEMATICS

Course Book for

Mathematics courses in

B. Arch. / B. Tech.

For

Academic Year
2026-2027

Visvesvaraya National Institute of Technology,
Nagpur-440 010

Institute Vision Statement

To contribute effectively to the National and International endeavor of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the Country and the World incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

Institute Mission Statement

The mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. VNIT is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

Department Vision Statement

- To be a leading Mathematics Department in the country.
- To emerge as a global center of learning, academic excellence, and innovative research.

Department Mission Statement

- Imparting of quality mathematics education and the inculcating of the spirit of research through innovative teaching and research methodologies.
- To achieve high standards of excellence in generating and propagating knowledge in Mathematics. Department is committed to providing an education that combines rigorous academics with joy of discovery.
- To provide an environment where students can learn, become competent users of mathematics, and understand the use of mathematics in other disciplines.

Brief about Department of Mathematics :

The Department of Mathematics VNIT Nagpur grew from its humble beginnings in the year 1960. The Department offers several courses in Mathematics to undergraduate and postgraduate students of various science and engineering disciplines. The Department commenced a two-year Master of Science (M.Sc.) program in Mathematics in 2012. Currently, the department has eleven full-time regular highly qualified, enthusiastic and energetic faculty members. All faculty members of the Department hold a PhD degree in Mathematics, with some of them having postdoctoral experience, from reputed institutes in India or abroad

List of faculty Members

Sr No	Faculty Name	Areas of specialization
1.	Dr. G. P. Singh	Relativity and Cosmology, Mathematical Modelling
2.	Dr. P. P. Chakravarthy	Numerical Analysis, Numerical Treatment of Singular Perturbation problems and Singularly Perturbed Differential-Difference equations
3.	Dr. Pallavi Mahale	Functional Analysis and Operator equations
4.	Dr. M.Devakar	Fluid Dynamics
5.	Dr. G. Naga Raju	Numerical Techniques for Partial Differential Equations; Spectral/Finite Element Techniques, Finite Volume Method, Parallel Computing
6.	Dr.Pradip Roul	Numerical analysis of singular BVP, Numerical methods for fractional ODE/PDE, Nuclear Reactor dynamics
7.	Dr. Deepesh Kumar Patel	Nonlinear Analysis, Fixed Point Theory
8.	Dr. Jyoti Singh	Commutative Algebra
9.	Dr. Sourav Pradhan	Queueing Theory; Stochastic Modeling
10.	Dr. Vishnu Pratap Singh	Operation research, Optimization under uncertainty
11.	Dr. Purnima Satapathy	Lie Groups and Lie Algebra, Partial Differential Equations
12.	Dr. Sourav Bhattacharya	Planar Topology, Dynamical Systems and Ergodic Theory
13.	Dr. Mohan Kumar Mallick	Nonlinear Elliptic PDEs
14.	Dr. NeelimaBhengra	Wave propagation Theory; Theoretical Seismology; Solid Mechanics

Credit System at VNIT :

Education at the Institute is organized around the semester-based credit system of study. The prominent features of the credit system are a process of continuous evaluation of a student's performance / progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation. A student's performance/progress is measured by the number of credits he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum number of credits and a minimum grade point average must be acquired by a student in order to qualify for the degree.

Course credits assignment

Each course, except a few special courses, has certain number of credits assigned to it depending on lecture, tutorial and laboratory contact hours in a week.
For Lectures and Tutorials: One lecture hour per week per semester is assigned one credit and
For Practical/ Laboratory/ Studio: One hour per week per semester is assigned half credit.
Example: Course XXXXXX with (3-0-2) as (L-T-P) structure, i.e. 3 hr Lectures + 0 hr Tutorial + 2 hr Practical per week, will have (3x1 + 0x1 + 2x0.5 =) 4 credits.

Grading System

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is based on fitting performance of the class to some statistical distribution. The course coordinator and associated faculty members for a course formulate appropriate procedure to award grades. These grades are reflective of the student's performance vis-à-vis instructor's expectation. If a student is declared pass in a subject, then he/she gets the credits associated with that subject.

Depending on marks scored in a subject, a student is given a Grade. Each grade has got certain grade points as follows:

Grade	Grade points	Description
AA	10	Outstanding
AB	9	Excellent
BB	8	Very good
BC	7	Good
CC	6	Average
CD	5	Below average
DD	4	Marginal (Pass Grade)
FF	0	Poor (Fail) /Unsatisfactory / Absence from end-sem exam
NP	-	Audit pass
NF	-	Audit fail
SS	-	Satisfactory performance in zero credit core course
ZZ	-	Unsatisfactory performance in zero credit core course
W	-	Insufficient attendance

Performance Evaluation

The performance of a student is evaluated in terms of two indices, viz, the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. CGPA is rounded up to second decimal.

The Earned Credits (ECR) are defined as the sum of course credits for courses in which students have been awarded grades between AA to DD. Grades obtained in the audit courses are not counted for computation of grade point average.

Earned Grade Points in a semester (EGP) = **Σ** (Course credits x Grade point) for courses in which AA- DD grade has been obtained

SGPA = EGP / Σ (Course credits) for courses registered in a semester in which AA- FF grades are awarded

CGPA= EGP / Σ(Course credits) for courses passed in all completed semesters in which AA- DD grades are awarded

Attendance Rules

1. All students must attend every class and 100% attendance is expected from the students. However, in consideration of the constraints/ unavoidable circumstances, the attendance can be relaxed by course coordinator only to the extent of not more than 25%. Every student must attend minimum of 75% of the classes actually held for that course.
2. A student with less than 75% attendance in a course during the semester, will be awarded W grade. Such a student will not be eligible to appear for the end semester and re-examination of that course. Even if such a student happens to appear for these examinations, then, answer books of such students will not be evaluated.
3. A student with W grade is not eligible to appear for end semester examination, reexamination & summer term.

Courses for B.Tech /B.Arch./M.Tech.

Semester – I

Sr. No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1	MALA 101/ MAL 101	Mathematics – I	DC	3-1-0	4
2	MALA 105	Mathematics (for B. Arch)	DC	3-1-0	4
3	MALA 103	Calculus and Differential Equations	BS	3-1-0	4
4	MALA 104	Calculus and Matrix Theory	BS	3-1-0	4

Semester - II

Sr. No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1.	MALA 102/ MAL 102	Mathematics – II	DC	3-1-0	4
2.	MALA 107	Mathematical Methods for Engineers	BS	3-1-0	4
3.	MALA 106	Complex Variables, Integral Transforms and Partial Differential Equations	DC	3-1-0	4

Semester – III & IV

Sr. No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1.	MAL 201	Integral Transforms and Partial Differential Equations	DC	3-1-0	4
2.	MAL 202	Complex variables and Partial Differential equations	DC	3-1-0	4
3.	MAL 203	Numerical Methods and Computation	DC	3-1-0	4
4.	MAL 205	Numerical Methods and Probability Theory	DC	3-1-0	4
5.	MAL 206	Linear Algebra and Applications	DC	3-1-0	4
6.	MALA 201/ MAL 208	Probability Theory and Statistical Methods	DC	3-1-0	4
7.	MAL 209	Discrete Mathematics and Graph Theory	DC	3-1-0	4
8.	MAL 210	Linear Algebra and Partial differential equations	DC	3-1-0	4
9.	MAL 211	Complex Variables, Integral Transforms and Partial Differential Equations	DC	3-1-0	4
10.	MALA 2XX	Numerical Methods and Computation Techniques	DC/DE	3-0-0	3

11.	MALA 2XX	Numerical Techniques and Probability Theory	DC/DE	3-0-0	3
12.	MALA 202	Probability Theory and Statistics	DC/DE	3-0-0	3
13.	MALA 203	Linear Algebra for Engineers	IE	3-0-0	3
14.	MALA 2XX	Mathematics for Machine Learning with Python	IE	2-0-2	3
15.	MALA 204	Optimization Techniques for Machine Learning	IE	3-0-0	3

Semester – V, VI, VII ,VIII & M. Tech.

Sr. No.	Course Code	Course Name	Type	Structure L-T-P	Credits
1.	MAL 301	Introduction to Operations Research	OC	3-0-0	4
2.	MAL 302	Fractional Calculus	OC	3-0-0	4
3.	MAL 303	Calculus of variations and Integral equations	OC	3-0-0	4
4.	MAL304	Financial Mathematics	OC	3-0-0	4
5.	MAL 305	Wavelet Analysis	OC	3-0-0	4
6.	MAL 401	Finite Difference methods for Differential Equations	OC	3-0-0	4
7.	MAL 403	Numerical Linear Algebra	OC	3-0-0	4
8.	MAL 406	Perturbation Methods	OC	3-0-0	4
9.	MAL 407	Statistics & Optimization Techniques	OC	3-0-0	4
10.	MAL 408	Statistical Analysis and Queuing Theory	OC	3-0-0	4
11.	MAL 409	Application of Operational Research Techniques in Construction Management		3-0-0	3
12.	MAL 410	Introduction to Finite Element Method	OC	3-0-0	4
13.	MAL 504	Applied Linear Algebra	DE	3-0-0	3
14.	MAL 505	Mathematical Elements for Engineers	DC	3-0-0	3
15.	MAL 506	Statistical Methods for Urban Planning	DC	3-0-0	3

MATHEMATICS-I

Course Code & Course Title:	**MALA101/ MAL 101 - MATHEMATICS-I**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech**		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose student to understand the basic importance of Differential calculus, Integral calculus, Infinite series and Matrix theory in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):** After completing this course students will be able to
CO1	test the convergence of sequence and series.
CO2	deal with differential calculus of functions of single variable and its applications.
CO3	understand concepts of integration of function of single variable and its applications.
CO4	understand basic concepts of matrix theory and can apply it to solve problems of Engineering.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Sequences and Series: Sequences of real and complex numbers, Monotonic sequence, Bounded Sequences, Convergence of Sequence. Infinite series, tests of convergence (Comparison test, Ratio test, Root test, Raabe's test, Logarithm test and Integral test statements only), absolute and conditional convergence, power series, radius of convergence.	CO1	4

Differential Calculus of function of single variable: Review of limit, continuity, and differentiability. Mean value theorems: Rolle's theorem, Lagrange's theorem, Cauchy's theorem, Taylor's theorem with Lagrange's form of remainder, curve tracing.	CO2	3
Integral Calculus: Fundamental theorem of Integral calculus, mean value theorems, evaluation of definite integrals. Differentiation under integral sign including variables limits-Leibnitz rule (without proof). Applications in area, length, volumes, and surface of solids of revolutions. Improper integrals and tests for convergence, Beta and Gamma functions,	CO3	3
Matrices: Gauss-Elimination and Gauss-Jordan Elimination methods for solving system of linear equations, Rank of matrix, consistency of a system of equations, linear dependence and independence, linear and orthogonal transformations, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, reduction to diagonal form, Hermitian and skew Hermitian matrices, Quadratic forms.	CO4	3

4. Text books

(i) E. Kreyszig, *Advanced Engineering Mathematics*, 8th Edition, John Wiley & Sons, ISBN: 0470458364

(ii) G.B. Thomas and R.L. Finney, *Calculus and Analytic Geometry*, 9th Edition, Addison Wesley Longman, Inc., Year of Publication, ISBN: 9788177583250

(iii) James Stewart, *Calculus: Early Transcendentals*, 5th Edition, Thomson Brooks/Cole (Indian Edition), 2007, ISBN: 9780534392277

(iv) R.K. Jain and S.R.K. Iyengar, *Advanced Engineering Mathematics*, Narosa Publishers, ISBN: 1842651854

5. Reference Book(s) and Other Required Material

i) N. Piskunov, *Differential and Integral Calculus (Vol. 1 & Vol. 2)*, MIR Publishers (Moscow) / CBS Publishers and Distributors (India), ISBN: 978-9390709236

ii) Sudhir R. Ghorpade and Balmohan V. Limaye, *A Course in Calculus and Real Analysis*, 2nd Edition, Springer, 2018, ISBN: 978-3030014001

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	3	2	1									2			
CO 2	3	2	1									2			
CO 3	3	2	1									2			
CO 4	3	2	1									2			

High - 3; Medium – 2; Low – 1;

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

MATHEMATICS-II

Course Code & Course Title:	**MALA102/ MAL 102 - MATHEMATICS-II**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech**		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose student to understand the basic importance of multi variable calculus (Differential calculus & Integral calculus), Vector calculus and ordinary differential equations in engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):** After completing this course students will be able to
CO1	deal with differential calculus of functions of several variables and their applications.
CO2	understand concepts of multiple integrals and their applications in Engineering problems.
CO3	understand the concepts of vector calculus and its applications in Engineering and Science.
CO4	solve certain class of ordinary differential equations related to Science and Engineering.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Calculus of function of Several Variables: Limit, continuity, and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, Tangent plane, and normal line. Euler's theorem on homogeneous functions, Total differentiation, chain rules, Jacobian, Taylor's formula, maxima and minima, saddle points, Lagrange's method of undetermined multipliers.	CO1	4

Multiple Integrals: Double integrals, change of order of integration, change of variables, application to area, volumes, Mass, Centre of gravity. Triple integrals, change of variables in triple integrals. Application of triple integral to find volume, mass, center of mass and moments of inertia about the axes of a solid.	CO2	3
Vector Calculus: Scalar and vector fields, gradient of scalar point function, directional derivatives, divergence, and curl of vector point function, solenoidal and irrotational motion. Vector integration: line, surface and volume integrals, Green's theorem, Stoke's theorem and Gauss divergence theorem (without proof).	CO3	3
Ordinary Differential Equations: First order differential equations: Exact equation, Integrating factors, Reducible to exact differential equations, Linear and Bernoulli's form, orthogonal trajectories, Existence and Uniqueness of solutions. Picard's theorem, Picard's iteration method of solution (Statements only). Solutions of second and higher order linear equations with constant coefficients, Linear independence and dependence, Method of variation of parameters, Solution of Cauchy's equation, simultaneous linear equations.	CO4	3

4. Text books

i) E. Kreyszig, *Advanced Engineering Mathematics*, 8th Edition, John Wiley & Sons, Year of Publication, ISBN: 0470458364

ii) G.B. Thomas and R.L. Finney, *Calculus and Analytic Geometry*, 9th Edition, Addison Wesley Longman, Inc., Year of Publication, ISBN: 9788177583250

iii) Michael D. Greenberg, *Advanced Engineering Mathematics*, Pearson Education Pvt. Ltd., Year of Publication, ISBN: 0133214311

iv) R.K. Jain and S.R.K. Iyengar, *Advanced Engineering Mathematics*, Narosa Publishers, Year of Publication, ISBN: 1842651854

5. Reference Book(s) and Other Required Material

i) N. Piskunov, *Differential and Integral Calculus (Vol. 1 & Vol. 2)*, MIR Publishers (Moscow) / CBS Publishers and Distributors (India), ISBN: 9390709236

ii) Sudhir R. Ghorpade and Balmohan V. Limaye, *A Course in Multivariable Calculus and Analysis*, Springer, 2010, ISBN: 978-3030014001

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	3	2	1									2			
CO 2	3	2	1									2			
CO 3	3	2	1									2			
CO 4	3	2	1									2			

High - 3; Medium – 2; Low – 1;

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

Mathematics (for B. Arch)

Course Code & Course Title:	**MALA105 Mathematics**		
Course Type:	**DC**		
Name of the programme(s):	**B. Arch**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**NIL**		
Course Equivalence: Course Code(s) & Name(s)	**NIL**		

1.	**Course Objective:** The objective of this subject is to equip the students with necessary mathematical background to comprehend the aspects of design elements and structural stability. Students can understand the basic concepts of geometry, matrix theory, basic statistics, differential and integral calculus.

2.	**Course Outcomes :**
CO1	To know the basic concepts of three-dimensional geometry.
CO2	To understand basic concepts of matrix theory and LPP and can apply it to solve problems of architecture.
CO3	To deal with problems related to central tendencies, dispersion and curve fitting.
CO4	To get the exposure to understand the concepts of calculus and its applications.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Three Dimensional Geometry: Directional Cosines and ratio's, angle between two lines, equations of straight line, coplanar lines, equation of plane, shortest distance between lines and planes, Sphere, Tangent plane, Plane section of a sphere.		CO1	3 Weeks
Matrices and Linear Programming: Review of inverse of a square matrix using Adjoint matrix, Rank of a matrix, Elementary rows and column transformation, Gauss elimination method, Consistency and inconsistency for system of linear equations, Formulation of Linear Programming, Solution of LPP using graphical method, Simplex method.		CO2	5 Weeks

Statistics: Measures of central tendency (Arithmetic mean, median, mode), measures of dispersion (standard deviation and variance), regression and correlation; Curve fitting, method of least squares (Straight line and parabola).	CO3	3Weeks
Calculus: Tangent and Normal, Maxima and minima of functions of one variable, Curvature, Taylor's and Maclaurin's expansion for one variable, Reduction Formulae, calculation of area using integrals (arc length and area under a curve).	CO4	4 Weeks

4. Text books

i) Grewal B.S., Higher Engineering Mathematics, Khanna Publishers, New Delhi, 201, ISBN: 9788193328491.

ii) Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics; Narosa Publishers 2005, ISBN: 1842651854.

iii) Thomas G.B., Calculus and Analytical Geometry, Addison Wesley, London, 1998, ISBN-13. 978-8174906168.

5. Reference Book(s) and Other Required Material

iii) Barratt, Krome, Logic and Design: In Art, Science & Mathematics, New York, NY :Design Press, 2005, ISBN-10 : 1592288499.

iv) Piskunov, N. : Differential and Integral calculus, Vol. 1, Vol. 2, MIR Publishers, Moscow - CBS Publishers and Distributors (India),1996, ISBN- 978-8123904924.

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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): NIL

Calculus and Differential Equations

Course Code & Course Title:	**MALA103 Calculus and Differential Equations**		
Course Type:	BS (Basic Science)		
Name of the programme(s):	B.Tech.		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)	Nil		
Course Equivalence: Course Code(s) & Name(s)	Nil		

1.	**Course Objective:** The objective of this subject is to expose students to understand the basic Differential calculus, Integral calculus of several variables and their applications in science and engineering.

2.	**Course Outcomes:**
CO1	Deal with differential calculus of functions of several variables and their applications.
CO2	Understand concepts of multiple integrals and their applications in Engineering problems.
CO3	Understand the concepts of vector calculus and its applications in Engineering and Science.
CO4	Solve a certain class of ordinary differential equations related to Science and Engineering.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Differential Calculus of Function of Several Variables: Partial derivatives and their geometrical interpretation, tangent plane and normal line, chain rules, Jacobian, Taylor's theorem (without proof), maxima and minima, saddle points.		CO1	3
Multiple Integrals: Double integrals, change of order of integration, change of variables, applications to area, volumes, mass, center of gravity. Triple integrals and change of variables in triple integrals. Application of triple integrals to volume, mass, center of mass, and moments of inertia.		CO2	4

Vector Calculus: Scalar and vector fields, gradient of scalar point function, directional derivatives, divergence, curl, solenoidal and irrotational fields. Vector integration: line, surface and volume integrals. Green's theorem, Stoke's theorem, and Gauss divergence theorem (without proof).	CO3	3
Ordinary Differential Equations: Second and higher order differential equations: linear equations with constant coefficients, linear independence and dependence, method of variation of parameters, Cauchy's equation.	CO4	3

4. Text books

v) E. Kreyszig, Advanced Engineering Mathematics, John Wiley Publications, 10th Edition, 2011, ISBN: 9780470458365.

vi) R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishers, 2005, ISBN: 9788173194385.

vii) James Stewart, Calculus: Early Transcendentals, 5th Edition, Thomson™ Brooks/Cole, 2007, ISBN: 9780534393212.

viii) G.B. Thomas and R.L. Finney, Calculus and Analytic Geometry, 9th Edition, Addison Wesley Longman, Inc, 1996, ISBN: 9780201531749.

5. Reference Book(s) and Other Required Material

iii) Ghorpade, S. R., and Limaye, B. V., A Course in Multivariable Calculus and Analysis, Springer, 2010, ISBN: 9781441916211.

iv) Greenberg, M. D., Advanced Engineering Mathematics, 2nd ed., Pearson Education, 2002, ISBN: 9780133214314.

v) Piskunov, N., Differential and Integral Calculus (Vol. 1 & Vol. 2), Mir Publishers/CBS Publishers and Distributors (India), 1974, ISBN: 9788123909158.

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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
CO1	3	2	1									2
CO2	3	2	1									2
CO3	3	2	1									2
CO4	3	2	1									2

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

Calculus and Matrix Theory

Course Code & Course Title:	**MALA 104 - Calculus and Matrix Theory**		
Course Type:	BS		
Name of the programme(s):	B.Tech.		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the basic importance of Differential calculus of functions of one and several variables, and Integral calculus functions of several variables, and Matrix theory in science and engineering.

2.	**Course Outcomes:** After completing this course students will be able to
CO1	deal with differential calculus of functions of several variables and their applications.
CO2	understand the concepts of vector calculus and its applications in Science and Engineering
CO3	understand concepts of multiple integrals and their applications in Science and Engineering problems.
CO4	understand basic concepts of matrix theory and can apply it to solve problems of Science and Engineering.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Differential Calculus of Function of Single variable: Review of calculus of function of single variable, Taylor's theorem with Lagrange's form of remainder	CO 1	1-2 Weeks
	Differential Calculus of Function of Several Variables: Partial derivatives, Tangent plane and normal line, chain rules, Jacobian, Taylor's theorem, maxima and minima, saddle points.	CO 2	2-3 Weeks

Vector Differential Calculus: Scalar and vector fields, gradient of scalar point function, divergence, and curl of vector point function, solenoidal and irrotational motion.	CO3	2-3 Weeks
Integral Calculus of Several Variables: Multiple Integrals: Double and Triple integrals, change of order of integration, change of variables, application to area, volumes, Mass, Centre of gravity. Vector integration: Line integral, Green's theorem.	CO3	3-4 Weeks
Matrices: Row Echelon form, Rank of matrix, consistency of a system of equations, Gauss-Elimination methods for solving systems of linear equations, linear dependence and independence, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, reduction to diagonal form.	CO4	3 Weeks

4.	Text books

i) Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics; Narosa Publishers, 2019, ISBN- 978-8184875607.
ii) James Stewart, Calculus-Early Transcendentals 5e, Thomson™ Brooks/Cole-Indian Edition, 2007, 978-0534274092
iii) Kreyszig, E, Advanced Engineering Mathematics (Eighth Edition); John Wiley & Sons. 1998, ISBN- 978-0471154969.
iv) Thomas, G.B. and Finney, R.L., Calculus and Analytic Geometry (Ninth Edition); Addison Wesley Longman, Inc. 1998, ISBN – 0-210-40015-4.

5.	Reference Book(s) and Other Required Material

i) Piskunov N., Differential and Integral calculus, Vol.1, Vol.2 MIR Publishers, Moscow – CBS Publishers and Distributors (India), 1996, ISBN- 978-8123904924.
ii) Sudhir R. Ghorpade, Balmohan V. Limaye, A Course in Calculus and Real Analysis, 2nd Edition, Springer, New York, NY. 2006, ISBN - 978-0387305301.

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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): NA

Mathematical Methods for Engineers

Course Code & Course Title:	**MALA 107 Mathematical Methods for Engineers**		
Course Type:	**BS**		
Name of the programme(s):	B.Tech.		
L – T – P	**3-1-0**	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the basic importance of ordinary differential equations, their numerical solutions, elementary statistics and probability in science and engineering.

2.	**Course Outcomes:** After completing this course students will be able to
CO1	Solve a certain class of ordinary differential equations related to Science and Engineering.
CO2	Apply various numerical techniques to solve transcendental and algebraic equations. Exploit numerical integration techniques for approximating the integrals.
CO3	Design and implement numerical methods to approximate the solutions of initial value problems and boundary value problems arising in science and engineering.
CO4	Solve problems related Conditional Probability, Independent events, Bayes Theorem occurring in science and engineering.
CO5	Deal with problems related to central tendencies, dispersion and curve fitting.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Order differential equations: First order differential equations: Exact equation, integrating factors, Reducible to exact differential equations, Linear and Bernoulli's form, orthogonal trajectories. Second and higher order differential equations: Solutions of second and higher order linear equations with constant coefficients, Linear independence and dependence, Wronskian, Method of variation of parameters, Solution of Cauchy's equation.	CO1	3-4

Solution of non-linear and Transcendental Equations: Bisection method, Regula-Falsi method, Secant method, Newton-Raphson method. **Numerical Integration**: Trapezoidal rule, Simpson's rule.	CO2	2-3
Numerical solutions of Differential Equations: Order differential equations: Initial value problems: Euler's method, Taylor's method, Runge-Kutta method. Boundary value problems: Finite difference approximations for first and second order derivatives, Finite difference methods.	CO3	3-4
Probability: Conditional Probability, Independent events, Bayes Theorem.	CO4	2
Statistics: Arithmetic mean, median, mode, standard deviation and variance, regression and correlation; Curve fitting, method of least squares (Straight line and parabola).	CO5	2

4.	**Text books**

i) Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics, 5h Edition, Narosa Publishers, 2022, ISBN: 9788184875607

ii) Jain, Iyengar and Jain: Numerical Methods for Engineers and Scientists, Wiley Eastern, 1985, ISBN: 978470201436.

5.	**Reference books**

i) Kreyszig, E. ; Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, 1998, ISBN: 978-0471154969.

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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
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

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

Complex Variables, Integral Transforms and Partial Differential Equations

Course Code & Course Title:	**MALA 106 Complex Variables, Integral Transforms and Partial Differential Equations**		
Course Type:	BS/DC/DE		
Name of the programme(s):	B.Tech.		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the importance of complex variables. It also focuses on partial differential equations and its applications in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):** After completing this course students will be able to
CO1	Analyse complex variable function's continuity, differentiability, analyticity and can compute complex integrals.
CO2	know the fundamentals of Laplace transform, inverse Laplace transform and its properties. Apply the Laplace transform techniques to solve ordinary differential equations.
CO3	understand the fundamental of Fourier series expansion and Fourier transform. Explore the properties of Fourier series & Fourier transform and its applications in Science and Engineering.
CO4	expose the concepts of the solutions to the PDE over the bounded domain.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Complex Variable: Functions of a complex variable - continuity, differentiability, analyticity. Zeros of an analytic function – singularities, Residue, Cauchy's residue theorem, complex integration - Cauchy's integral theorem (statement only), Cauchy's integral formula (statement		**CO1**	4

only), Taylor's theorem - Laurent's theorem (statement only), contour integration.		
Laplace Transforms: Definition of Laplace Transforms, Linearity property, condition for existence of Laplace transform, first and second shifting properties, transforms of derivatives and integrals, evaluation of integrals by Laplace transform. Inverse Laplace transform, convolution theorem, Laplace transform of periodic functions, unit step function and Dirac delta function. Applications of Laplace transform to solve ordinary differential equations.	**CO2**	3
Fourier Series and Fourier Transforms: Fourier series, half range Sine and Cosine series expansions, exponential form of Fourier series. Fourier integral theorem, Fourier transform, Fourier Sine and Cosine Transforms, Linearity, scaling, frequency shifting and time shifting properties, convolution theorem.	**CO3**	3
Partial Differential Equations: Classification of linear second order PDEs, method of separation of variables, Solution of One-dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms).	**CO4**	4

4.	**Text books**

iv) J.W. Brown and R.V. Churchill, Complex Variables and Applications, McGraw Hill, 9th Edition, 2009, ISBN-13. 978-0073383170.

v) R.K. Jain, and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishers, 2005, ISBN-13. 978-8184875607.

vi) E. Kreyszig, Advanced Engineering Mathematics, John Wiley publications, 10th Edition, 2011, ISBN: 978-0-470-45836-5.

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

v) E.T. Copson, Theory of Complex Variables, Oxford University Press,1988.

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

Weightage: Mid semester: 20-30%, Internal Assessment: 10-20%, End semester: 50-60%

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
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): NA**

Integral Transforms and Partial Differential Equations

Course Code & Course Title:	**MAL201, Integral Transforms and Partial Differential Equations**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech**		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose student to understand the importance of transform techniques to solve real world problems. It also focuses the partial differential equations and its applications in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	know the fundamentals of Laplace transform, inverse Laplace transform and its properties. Apply the Laplace transform techniques to solve ordinary differential equations.
CO2	understand the fundamentals of Fourier series expansion and Fourier transform. Explore the properties of Fourier series & Fourier transform and its applications in Science and Engineering.
CO3	expose the concepts of the solutions to the PDE over the bounded domain.
CO4	understand the fundamentals and applications of Z-transform.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Laplace Transforms: Definition of Laplace Transforms, Linearity property, condition for existence of Laplace Transform, first and second shifting properties, transforms of derivatives and integrals, evaluation of integrals by Laplace Transform. Inverse Laplace Transform, convolution theorem, Laplace Transform of periodic functions, unit step function and Dirac delta function. Applications of Laplace Transform to solve ordinary differential equations.		CO1	4

Fourier Series and Fourier Transforms: Fourier series, half range sine and cosine series expansions, exponential form of Fourier series. Fourier integral theorem, Fourier transform, Fourier Sine and cosine Transforms, Linearity, scaling, frequency shifting and time shifting properties, convolution theorem.	CO2	3
Partial differential equations: Classification of linear second order PDEs, method of separation of variables, Solution of One-dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms), D'Alembert solution of wave equation.	CO3	4
Z-transform: Z - transform, Properties of Z-transforms, Convolution of two sequences, inverse Z-transform, Solution of Difference equations.	CO4	2

4. Text books

ix) Erwin Kreyszig, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, 1999, ISBN: 978-0471154963

x) R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, 3rd Edition, Narosa Publishing House, 2009, ISBN: 978-8184872068

5. Reference Book(s) and Other Required Material

vi) G.B. Thomas and R.L. Finney, Calculus and Analytic Geometry, 9th Edition, Addison Wesley Longman, Inc., 1996, ISBN: 978-0201531743

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1															
CO 2															
CO 3															

CO 4															
CO 5															

High - 3; Medium – 2; Low – 1;

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

Complex Variables and Partial Differential Equations

Course Code & Course Title:	**MAL202, Complex Variables and Partial Differential Equations**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech**		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose student to understand the importance of complex variables. It also focuses the partial differential equations and its applications in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	know the fundamentals of Laplace transform, inverse Laplace transform and its properties. Apply the Laplace transform techniques to solve ordinary differential equations.
CO2	understand the fundamentals of analytic function, complex integration, residue theorem.
CO3	understand the fundamentals of Fourier series expansion and Fourier transform. Explore the properties of Fourier series & Fourier transform and its applications in Science and Engineering
CO4	expose the concepts of the solutions to the PDE over the bounded domain.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Laplace Transforms: Definition of Laplace Transforms, Linearity property, condition for existence of Laplace Transform, first and second shifting properties, transforms of derivatives and integrals, evaluation of integrals by Laplace Transform. Inverse Laplace Transform, convolution theorem, Laplace Transform of periodic functions, unit step function and Dirac delta function. Applications of Laplace Transform to solve ordinary differential equations.		CO1	3

Complex variable: Functions of a complex variable - continuity - differentiability - analytic functions - complex integration - Cauchy's integral theorem. Cauchy's integral formula, Taylor's theorem - Laurent's theorem, zeros of an analytic function – singularities, Residue - Cauchy's residue theorem - contour integration.	CO2	4
Fourier Series and Fourier Transforms: Fourier series, half range sine and cosine series expansions, exponential form of Fourier series. Fourier integral theorem, Fourier transform, Fourier Sine and cosine Transforms, Linearity, scaling, frequency shifting and time shifting properties, convolution theorem.	CO3	3
Partial differential equations: Classification of linear second order PDEs, method of separation of variables, Solution of One-dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms), D'Alembert solution of wave equation.	CO4	3

4. Text books

i) E. Kreyszig, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, 1998, ISBN: 978-0471154963

ii) R.V. Churchill and J.W. Brown, Complex Variables and Applications, 7th Edition, McGraw-Hill, 2001, ISBN: 978-0072292347

5. Reference Book(s) and Other Required Material

i) R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2005, ISBN: 978-8173197813

ii) E.T. Copson, Theory of Functions of a Complex Variable, Oxford University Press, 1988, ISBN: 978-0198535663

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3

CO 1															
CO 2															
CO 3															
CO 4															
CO 5															

High - 3; Medium – 2; Low – 1;

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

Numerical Methods and Computation

Course Code & Course Title:	**MAL203, Numerical Methods and Computation**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech**		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to make the students aware of the numerical methods for the solution of scientific problems which cannot be solved analytically.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Apply different interpolation techniques in the engineering problems.
CO2	Exploit numerical integration techniques for approximating the integrals.
CO3	Apply various numerical techniques to solve transcendental and algebraic equations.
CO4	Solve system of linear algebraic equations, nonlinear system of equations and eigenvalue problems.
CO5	Design and implement numerical methods to approximate the solutions of initial value problems and boundary value problems arising in engineering

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Interpolation: Existence, Uniqueness of interpolating polynomial, error of interpolation - unequally spaced data; Lagrange's formula, Newton's divided difference formula. Equally spaced data: finite difference operators and their properties, Gauss's forward and backward, Sterling's formulae - Inverse interpolation - Hermite interpolation.	CO1	3
	Differentiation: Finite difference approximations for first and	CO2	2

second order derivatives.		
Integration: Newton-cotes closed type methods; particular cases, error terms - Newton cotes open type methods - Romberg integration Gaussian quadrature; Legendre formulae.	CO3	2
Solution of nonlinear and transcendental equations: Regula Falsi method, Newton-Raphson method, Newton Raphson method for system of nonlinear equations.	CO4	3
Solution of linear algebraic system of equations: LU Decomposition, Gauss-Seidal methods; solution of tridiagonal system. Ill conditioned equations. Eigen values and eigen vectors : Power and Jacobi methods.	CO5	3

4. Text books

i) R.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Engineers and Scientists, Wiley Eastern, 1984, ISBN: 978-8122400896

ii) S.D. Conte and C. de Boor, Elementary Numerical Analysis: An Algorithmic Approach, 3rd Edition, McGraw-Hill, 1980, ISBN: 978-0070124473

5. Reference Book(s) and Other Required Material

i) C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, 7th Edition, Addison-Wesley, 2004, ISBN: 978-0321183150

ii) K.E. Atkinson, An Introduction to Numerical Analysis, 2nd Edition, John Wiley & Sons, 1989, ISBN: 978-0471624893

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1															
CO 2															

CO 3															
CO 4															
CO 5															

High - 3; Medium – 2; Low – 1;

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

Numerical Methods and Probability Theory

Course Code & Course Title:	**MAL 205- Numerical Methods and Probability Theory**		
Course Type:	**DC**		
Name of the programme(s):	B. Arch. / B. Tech.		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The broad objective of the course is to teach basic concepts of the numerical methods, their rate of convergence and applications to physical problems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Employ a number of techniques to solve transcendental and algebraic equations. Know how to solve a system of nonlinear equations by Newton-Raphson method.
CO2	Efficiently solve a system of linear equations and find their eigenvalues and eigenvectors. Design and implement numerical methods for numerical approximation of initial value problems as well as two-point boundary value problems.
CO3	Apply the concepts such as random variables, probability density function, cumulative distribution function, and joint probability density function in the engineering and science problems.
CO4	Analyse and apply the concepts such as mathematical expectation, functions of random variables, variance, standard deviations, moment generating function, Skewness and Kurtosis. Exploit different probability distributions such as Binomial, Geometric distribution, Poisson distribution, and normal distribution in the engineering and science problems.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**

Solutions of algebraic and transcendental equations by Iteration method, method of false position, Newton-Raphson method and their convergence.	**CO1**	3
Solutions of system of linear equations by Gauss elimination method, Gauss Seidal method, LU decomposition method. Newton-Raphson method for system of nonlinear equations. Eigen values and eigen vectors: Power and Jacobi methods. Numerical solution of ordinary differential equations: Taylor's series method, Euler's modified method, Runge-Kutta method, Adam's Bashforth and Adam's Moulton, Milne's predictor corrector method. Boundary value problems: Shooting method, finite difference methods.	**CO2**	4
Random variables, discrete and continuous random variable, probability density function; probability distribution function for discrete and continuous random variable joint distributions. Definition of mathematical expectation, functions of random variables, The variance and standard deviations, moment generating function other measures of central tendency and dispersion	**CO3**	3
Skewness and Kurtosis. Binomial, Geometric distribution, Poisson distribution, Relation between Binomial and Poisson's distribution, Normal distribution, Relation between Binomial and Normal distribution. Introduction to Stochastic Processes.	**CO4**	3

4.	**Text books**

vii) S. D. Cante and C. de Boor, Elementary Numerical Analysis: an algorithmic approach, 3rd Edition, McGraw-Hill, 1980, ISBN: 978-0070124479.

viii) Jain, Iyengar and Jain: Numerical Methods for Engineers and Scientists, 3rd Edition, Wiley, Eastern, 2013, ISBN: 978-1118554937

ix) V.K. Rohatgi and A.K.M.E Saleh: An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons, 2015, ISBN: 978-1118799642

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

vi) Gerald and Wheatley, Applied Numerical Analysis, 7th Edition, Addison-Wesley, 2003, ISBN: 978-0321133045

vii) K.S. Trivedi: Probability Statistics with Reliability, Queuing and Computer Science applications, 2nd Edition, John Wiley & Sons, 2001. ISBN: 978-0471333418

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Linear Algebra and Applications

Course Code & Course Title:	**MAL206 - Linear Algebra and Applications**		
Course Type:	**DC**		
Name of the programme(s):	B. Arch. / B. Tech.		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the basic importance of Linear Algebra and its applications its applications to science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Apply the matrix calculus in solving a system of linear algebraic equations
CO2	Understand the basic concepts of linear algebra such as vector space, basic vector operations, basis, dimension and Linear transformations etc
CO3	Relate matrices and linear transformations, compute Eigen values and Eigen vectors of linear transformations and obtain various variants of diagonalisation of linear transformations.
CO4	Learn properties of inner product spaces and determine orthogonality in inner product spaces.
CO5	Understand the importance of linear algebra and its applications to science and engineering

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Matrices: Review of Matrix Algebra; Rank of matrix; Row reduced Echelon form; Determinants and their properties; Solution of the matrix Equation Ax = b; Gauss elimination method.		**CO1**	2

Vector space, subspaces, linear dependence/independence, basis, dimension, linear transformation, range space and rank, null space and nullity, rank nullity theorem. matrix representation of a linear transformation, linear operators on R^n and their representation as square matrices, invertible linear operators, inverse of a non-singular matrix.	**CO2**	3
Eigen values and eigenvectors of a linear operator, properties of eigen values and eigenvectors of Hermitian, skew-Hermitian, unitary, and normal matrices (symmetric, skew-symmetric, and orthogonal matrices), characteristic equation, bounds on eigen values, Cayley-Hamilton theorem, diagonalizability of a linear operator, invariant sub spaces, annihilators, minimal polynomials.	**CO3**	4
Inner product spaces, norm; ortho normal sets, Gram-Schmidt orthogonalization process; projections and least squares approximation, Ad-joint operator, normal, unitary and self-adjoint operator. Spectral theorem for normal operator, applications of linear algebra in engineering.	**CO4, CO5**	4

4. Text books

i) E. Kreyszig, Advanced engineering mathematics, 10th Edition, John Wiley & Sons, 2011, ISBN: 978-0470458365.

ii) G. Strang, Linear algebra and its applications, 4th Edition, Thomson Publications, 2006, ISBN: 978-0534422004.

5. Reference Book(s) and Other Required Material

i) Hoffman and Kunje, Linear Algebra, 2nd Edition, Prentice Hall of India, 2004, ISBN: 978-8120302709.

ii) S. Kumaresan, Linear algebra - A Geometric approach, 1st Edition, Prentice Hall of India, 2000, 978-8120316287.

viii) Nagpaul, First course in Linear Algebra, 1st Edition, Wiley Eastern Ltd, New Delhi, 1991, ISBN: 978-0852260623.

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Probability Theory and Statistical Methods

Course Code & Course Title:	**MALA 201/ MAL 208 – Probability Theory and Statistical Methods**		
Course Type:	**DC**		
Name of the programme(s):	B. Arch. / B. Tech.		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the importance of probability theory and statistical analysis in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the significance of probability and statistics in real life, engineering and industrial applications, also will be able to grab the theoretical foundations of conditional probability, random variables, joint distributions, transformations.
CO2	Learn some significant special discrete and continuous distributions.
CO3	Be able to use sampling theory, estimation, decision making and regression.
CO4	Formulate probabilistic and statistical models of real life/ engineering problems and use them

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Random Variable & Probability Distributions: Random Variables, Density function, distribution function for continuous and discrete random variables, Mathematical Expectation: Mathematical Expectation, The variance and Standard deviation, Moment Generating Function, Characteristic Function. Joint distributions, Moments, correlation, covariance and regression.		**CO1**	3

Special Probability Distributions: Some special probability distributions like Binomial Poisson, Geometric, Normal, Uniform, Exponential, Gamma, Beta, Chi-Square, Students't', F-distribution and Weibull Distribution.	**CO2**	4
Sampling Theory: Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, The Sample variance, The sampling distribution of variance. Estimation Theory: Point estimate and Interval Estimates, Reliability, Confidence interval estimates of population parameters, confidence intervals for means, proportions and variance.	**CO3**	3
Tests of Hypothesis and Significance: Statistical decisions, Tests of hypothesis and significance. Type I and Type II errors. Level of significance, one tailed and two tailed tests. Tests involving small samples and large samples. Fitting theoretical distributions to sample frequency distribution. The chi-square test for goodness of fit.	**CO4**	3

4. Text books

i) Miller and Freund: Probability and Statistics for Engineers, 8th Edition, Prentice Hall of India, 2011, ISBN: 978-8120342132.

ii) V.K. Rohatgi and A.K.M.E Saleh: An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons, 2015, ISBN: 978-1118799642

5. Reference Book(s) and Other Required Material

i) Paul L. Meyer, Introductory Probability and Statistical Applications, 2nd Edition, Addison Wesley, 1970, ISBN: 978-0201047103.

ii) E.Parzen: Modern Probability Theory and Its Applications, 1st Edition, John Wiley and Sons, New York, 1992, ISBN: 978-0471668251.

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

Mid Sem: 30 Marks

Internal: 20 Marks

End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Discrete Mathematics and Graph Theory

Course Code & Course Title:	**MAL209 , Discrete Mathematics and Graph Theory**		
Course Type:	**DC**		
Name of the programme(s):			
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to make the students aware of sets, relations, functions, Boolean algebra and graph theory and its applications in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the fundamentals of logic, recurrence relations and their solutions.
CO2	Learn about equivalence relations and partitions, and Warshal's algorithm.
CO3	Be able to learn Boolean lattices and algebras, uniqueness of finite Boolean algebras.
CO4	Understand the spanning trees, BFS & DFS algorithms, minimum spanning trees and Prims & Kruskal's algorithms.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Sets and propositions: Combinations of sets, Finite and Infinite sets, uncountable infinite sets, principle of inclusion and exclusion, mathematical induction. Propositions, fundamentals of logic, first order logic, ordered sets. Permutations, combinations, numeric functions, generating functions. Recurrence relations and recursive algorithms: recurrence relations, linear recurrence relations with constant coefficients, homogeneous solutions, particular solutions, total solutions, solution by the method	**CO1**	3

of generating functions, sorting algorithm.		
Relations and functions: properties of binary relations, equivalence relations and partitions, partial and total ordering relations, Transitive closure and Warshal's algorithm.	**CO2**	3
Boolean algebra: Chains, Lattices and algebraic systems, principle of duality, basic properties of algebraic systems, distributive and complemented lattices, Boolean lattices and algebras, uniqueness of finite Boolean algebras, Boolean expressions and functions.	**CO3**	3
Graphs and planar graphs: Basic terminology, multigraphs and weighted graphs, paths and circuits, shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits. Colorable graphs, Chromatic numbers, Five color theorem and Four-color problem. Trees and cut-sets: trees, rooted trees, path lengths in rooted trees, spanning trees and BFS & DFS algorithms, minimum spanning trees and Prims & Kruskal's algorithms.	**CO4**	4

4. Text books

i) Mott, Kandel and Baker, Discrete Mathematics for Computer Scientists, 2nd Edition, PHI, 2008, ISBN:9788120315020.
ii) Tremblay and Manohar, Discrete Mathematical Structures with applications to Computer Science, 1st Edition, McGraw Hill Book Co, 1975, ISBN: 9780070651425.

5. Reference Book(s) and Other Required Material

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Linear Algebra and Partial differential equations

Course Code & Course Title:	**MAL 210 , Linear Algebra and Partial differential equations**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech**		
L – T – P	3-1-0	**No. of Credits**	**4**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the basic importance of Linear Algebra and its applications its applications to science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the basic concepts of linear algebra such as vector space, basic vector operations, basis, dimension and Linear transformations etc
CO2	Relate matrices and linear transformations, compute Eigen values and Eigen vectors of linear transformations and obtain various variants of diagonalization of linear transformations
CO3	Understand the fundamentals of Fourier series expansion and Fourier transform. Explore the properties of Fourier series & Fourier transform and its applications in Science and Engineering.
CO4	Expose the concepts of the solutions to the PDE over the bounded domain.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Vector space, subspaces, linear dependence/independence, basis, dimension, linear transformation, range space and rank, null space and nullity, rank nullity theorem. matrix representation of a linear transformation, linear operators on R^n and their representation as square matrices, invertible linear operators, inverse of a non-singular		**CO1**	3

transformations.		
Eigenvalues and eigenvectors of a linear operator, characteristic equation, bounds on Eigenvalues, diagonalizability of a linear operator, invariant subspaces, annihilators, minimal polynomials. Inner product spaces, vector and matrix norms; orthonormal sets, Gram-Schmidt orthogonalization process; projections and least squares approximation, Adjoint operator, normal, unitary and self-adjoint operator., Spectral theorem for normal operator, Singular Value Decompositions, QR decomposition.	**CO2**	4
Fourier series, half range sine and cosine series expansions, exponential form of Fourier series.	**CO3**	3
Classification of linear second order partial differential equations, method of separation of variables, Solution of One-dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms).	**CO4**	3

4. Text books

i) E. Kreyszig, Advanced engineering mathematics, 10th Edition, John Wiley & Sons, 2011, ISBN: 978-0470458365.
ii) G. Strang, Linear algebra and its applications, 4th Edition, Thomson Publications, 2006, ISBN: 978-0534422004.

5. Reference Book(s) and Other Required Material

i) H. Anton, Elementary Linear Algebra, 11th Edition, John Wiley & Sons, New York, 2019, ISBN: 978-1118473504.
ii) Hoffman and Kunje, Linear Algebra, 2nd Edition, Prentice Hall of India, 2004, ISBN: 978-8120302709.
iii) Jain, R.K. and Iyengar, S.R.K.; Advanced Engineering Mathematics, 2nd Edition, Narosa Publishers, 2005, SBN: 9781842651858.
iv) S. Kumaresan, Linear algebra - A Geometric approach, 1st Edition, Prentice Hall of India, 2000, 978-8120316287.

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Complex Variables, Integral Transforms and Partial Differential Equations

Course Code & Course Title:	**MAL211, Complex Variables, Integral Transforms and Partial Differential Equations**		
Course Type:	BS/DC/DE		
Name of the programme(s):	B.Tech.		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the importance of complex variables. It also focuses on partial differential equations and its applications in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):** After completing this course students will be able to
CO1	Analyse complex variable function's continuity, differentiability, analyticity and can compute complex integrals.
CO2	know the fundamentals of Laplace transform, inverse Laplace transform and its properties. Apply the Laplace transform techniques to solve ordinary differential equations.
CO3	understand the fundamental of Fourier series expansion and Fourier transform. Explore the properties of Fourier series & Fourier transform and its applications in Science and Engineering.
CO4	expose the concepts of the solutions to the PDE over the bounded domain.
CO5	To know the fundamentals of Z-transform and its properties & to apply the Z-transform to solve the practical problem.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**

Complex Variable: Functions of a complex variable - continuity, differentiability, analyticity. Zeros of an analytic function – singularities, Residue, Cauchy's residue theorem, complex integration - Cauchy's integral theorem (statement only), Cauchy's integral formula (statement only), Taylor's theorem - Laurent's theorem (statement only), contour integration.	**CO1**	4
Laplace Transforms: Definition of Laplace Transforms, Linearity property, condition for existence of Laplace transform, first and second shifting properties, transforms of derivatives and integrals, evaluation of integrals by Laplace transform. Inverse Laplace transform, convolution theorem, Laplace transform of periodic functions, unit step function and Dirac delta function. Applications of Laplace transform to solve ordinary differential equations.	**CO2**	3
Fourier Series and Fourier Transforms: Fourier series, half range Sine and Cosine series expansions, exponential form of Fourier series. Fourier integral theorem, Fourier transform, Fourier Sine and Cosine Transforms, Linearity, scaling, frequency shifting and time shifting properties, convolution theorem.	**CO3**	3
Partial Differential Equations: Classification of linear second order PDEs, method of separation of variables, Solution of One-dimensional wave equation, heat equation, Laplace equation (Cartesian and polar forms).	**CO4**	4
Z-transform: Z - transform, Properties of Z-transforms, Convolution of two sequences, inverse Z transform, Solution of Difference equations.	**CO5**	2

4.	**Text books**

x) J.W. Brown and R.V. Churchill, Complex Variables and Applications, McGraw Hill, 9th Edition, 2009, ISBN-13. 978-0073383170.

xi) R.K. Jain, and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishers, 2005, ISBN-13. 978-8184875607.

xii) E. Kreyszig, Advanced Engineering Mathematics, John Wiley publications, 10th Edition, 2011, ISBN: 978-0-470-45836-5.

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

ix) E.T. Copson, Theory of Complex Variables, Oxford University Press,1988.

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

Weightage: Mid semester: 20-30%, Internal Assessment: 10-20%, End semester: 50-60%

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
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): NA**

Numerical Methods and Computation Techniques

Course Code & Course Title:	**MALA2XX - Numerical Methods and Computation Techniques**		
Course Type:	**DC/DE**		
Name of the programme(s):	**B.Tech**		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**NA**		
Course Equivalence: Course Code(s) & Name(s)	**NA**		

1.	**Course Objective:** The objective of this subject is to make the students aware of the numerical methods for the solution of scientific problems which cannot be solved analytically.

2.	**Course Outcomes:**
CO1	Apply different interpolation techniques in the engineering problems.
CO2	Exploit numerical integration techniques for approximating the integrals.
CO3	Apply various numerical techniques to solve transcendental and algebraic equations.
CO4	Solve system of linear algebraic equations, nonlinear system of equations and eigenvalue problems.
CO5	Design and implement numerical methods to approximate the solutions of initial value problems and boundary value problems arising in engineering

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Interpolation: Existence, Uniqueness of interpolating polynomial, error of interpolation - unequally spaced data; Lagrange's formula, Newton's divided difference formula. Equally spaced data: finite difference operators and their properties, Inverse interpolation - Hermite interpolation.		**CO1**	3
Differentiation: Finite difference approximations for first and second order derivatives.		**CO2**	2

Integration: Newton-cotes closed type methods; particular cases, error terms - Newton cotes open type methods - Gaussian quadrature; Legendre formulae.		
Solution of nonlinear and transcendental equations: Regula Falsi method, Newton-Raphson method.	**CO3**	2.5
Solution of linear algebraic system of equations: LU Decomposition, Jacobi and Gauss-Seidal methods; solution of tridiagonal system. Eigen values and eigen vectors: Power methods.	**CO4**	3
Solution of Ordinary differential equations: Initial value problems: Single step methods; Taylor's, Euler's, Runge-Kutta methods, Boundary value problems: Finite difference methods.	**CO5**	2.5

4. Text books

xi) K. E. Atkinson, *An Introduction to Numerical Analysis*, 2nd Edition, John Wiley & Sons, 1989, ISBN: 9780471043386

xii) M.K. Jain, S.R.K. Iyengar, and R.K. Jain, *Numerical Methods for Engineers and Scientists*, 6th Edition, New Age International Publishers, 2007, ISBN: 9788122422239.

5. Reference Book(s) and Other Required Material

i) Curtis F. Gerald and Patrick O. Wheatley, *Applied Numerical Analysis*, 7th Edition, Addison-Wesley, 2004, ISBN: 9780321133045.

ii) S.D. Conte and Carl de Boor, *Elementary Numerical Analysis: An Algorithmic Approach*, 3rd Edition, McGraw-Hill, 1980, ISBN: 9780070124464.

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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
CO1	3	2	1	0	0	0	0	0	0	0	0	1
CO2	3	2	1	0	0	0	0	0	0	0	0	1
CO3	3	2	1	0	0	0	0	0	0	0	0	1
CO4	3	2	1	0	0	0	0	0	0	0	0	1
CO5	3	2	1	0	0	0	0	0	0	0	0	1

High - 3; Medium – 2; Low – 1;

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

Numerical Techniques and Probability Theory

Course Code & Course Title:	**MALA 2XX, Numerical Techniques and Probability Theory**		
Course Type:	DC/DE		
Name of the programme(s):	B.Tech		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The broad objective of the course is to teach basic concepts of the numerical methods, their rate of convergence and applications to physical problems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Employ a number of techniques to solve transcendental and algebraic equations. Know how to solve a system of nonlinear equations by Newton-Raphson method.
CO2	Efficiently solve a system of linear equations and find their eigenvalues and eigenvectors. Design and implement numerical methods for numerical approximation of initial value problems as well as two-point boundary value problems.
CO3	Apply the concepts such as random variables, probability density function, cumulative distribution function, and joint probability density function in the engineering and science problems.
CO4	Analyse and apply the concepts such as mathematical expectation, functions of random variables, variance, standard deviations, moment generating function, Skewness and Kurtosis. Exploit different probability distributions such as Binomial, Geometric distribution, Poisson distribution, and normal distribution in the engineering and science problems.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Numerical Analysis: Solutions of algebraic and transcendental equations by Iteration method, method of false position, Newton - Raphson method for solving single and system of equations.		CO-1	2

Solutions of system of linear equations by Gauss elimination method, LU decomposition method, Gauss Seidel method. Eigen values and eigen vectors: Power method.	CO-2	1
Numerical solution of ordinary differential equations: Taylor's series method, Euler's method, Runge-Kutta method.	CO-2	3
Boundary value problems: Finite difference methods.	CO-2	1
Probability theory: Random variables, discrete and continuous random variables, probability density function, probability distribution function for discrete and continuous random variables, joint distributions.	CO-3	2
Definition of mathematical expectation. The variance and standard deviation.	CO-4	1
Moment generating function, other measures of central tendency and dispersion, Skewness, and Kurtosis.	CO-4	1
Binomial, Geometric distribution, Poisson distribution, Relation between Binomial and Poisson's distribution, Normal distribution, Relation between Binomial and Normal distribution.	CO-4	2

4.	**Text books**

i) Gerald and Wheatley, Applied Numerical Analysis, 3rd Edition, Addison-Wesley, 1984, ISBN-0201115778

ii) Jain, Iyengar, and Jain, Numerical Methods for Engineers and Scientists, 2nd Edition, Wiley Eastern, 1985, ISBN-0852264348.

iii) V.K. Rohatgi and A.K.M. Ehsane, An Introduction to Probability and Statistics, 2nd Edition, John Wiley & Sons, 2011, ISBN-1118165683..

iv) Spiegel, M.R., Theory and problems of Probability and statistics, McGraw-Hill Book Company, 2003, ISBN-0070586101

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

i) S. D. Cante and C. de Boor, Elementary Numerical Analysis, an algorithmic approach, Reprint Edition, McGraw-Hill, 2018, ISBN-1611975204.

ii) K.S. Trivedi, Probability Statistics with Reliability, Queuing and Computer Science applications, 2nd Edition, Prentice Hall of India Pvt. Ltd, 2016, ISBN-1119314208.

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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
CO1	3	3	3	1	1	2	---	---	---	---	---	1
CO2	3	3	3	1	1	2	---	---	---	---	---	1
CO3	3	3	3	1	1	2	---	---	---	---	---	1
CO4	3	3	3	1	1	2	---	---	---	---	---	1

High - 3; Medium – 2; Low – 1;

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

Probability Theory and Statistics

Course Code & Course Title:	**MALA202, Probability Theory and Statistics**		
Course Type:	**DC/DE**		
Name of the programme(s):	B.Tech.		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose student to understand the importance of probability theory and statistical analysis in science and engineering.

2.	**Course Outcomes :**
CO1	Understand the significance of probability and statistics in real life, engineering and industrial applications.
CO2	Be able to grab the theoretical foundations of conditional probability, random variables, joint distributions, transformations
CO3	Learn some significant special discrete and continuous distributions.
CO4	Be able to use sampling theory, estimation, and regression.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Random Variable & Probability Distributions: Random Variables, Probability Mass/Density function, distribution function. Mathematical Expectation: Expectation, the variance, Moments, Moment Generating Function, Characteristic Function. Joint distributions, marginal/conditional distributions, covariance, correlation.		CO1, CO2	5
Special Probability Distributions: Binomial, Poisson, Geometric, Normal, Uniform, Exponential.		CO3	5

Sampling Theory: Sample mean/variance, Sample moments, Sampling distributions of mean and variance. Chi-Square, Students't', F-distribution. Estimation Theory: Point estimate and Interval Estimates, Confidence interval estimates of population parameters, confidence intervals for means, proportions and variance. Linear Regression: Least square method for curve fitting, Properties of linear regression.	CO4	4

4. Text books

i) E. Parzen: Modern Probability Theory and Its Applications J. Wiley and Sons Inc., New York, 1960, ISBN-978-0471668251.

ii) Miller and Freund: Probability and Statistics for Engineers, Pearson Education Limited, New York, 2018,ISBN- 978-8120342132.

iii) M. R. Spiegel: Probability and Statistics, McGraw-Hill, 1995, ISBN- 978-0070151543 .

5. Reference Book(s) and Other Required Material

i) Paul L. Meyer, Introductory Probability and Statistical Applications, Addison Wesley, 1970, SBN-13, 978-0201047103.

ii) V. K. Rohatgi and A.K.M.E. Saleh: An Introduction to Probability and Statistics, John Wiley & Sons, 2001 ISBN:9780471348467..

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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
CO1	3	3	3	1	1	2	---	---	---	---	---	1
CO2	3	3	3	1	1	2	---	---	---	---	---	1
CO3	3	3	3	1	1	2	---	---	---	---	---	1
CO4	3	3	3	1	1	2	---	---	---	---	---	1

High - 3; Medium – 2; Low – 1;

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

Linear Algebra for Engineers

Course Code & Course Title:	**MALA 203 & Linear Algebra for Engineers**		
Course Type:	**IE**		
Name of the programme(s):	B.Tech.		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the basic importance of Linear Algebra and its applications to engineering.

2.	**Course Outcomes:**
CO1	Understand the basic concepts of linear algebra such as vector space, basic vector operations, basis, dimension and Linear transformations etc
CO2	Relate matrices and linear transformations, compute Eigen values and Eigen vectors of linear transformations and obtain various variants of diagonalization of linear transformations
CO3	Learn properties of inner product spaces and determine orthogonality in inner product spaces and its applications to QR-factorization, Best approximation and least squares.
CO4	Understand the importance of linear algebra and its applications to various problems occurring in engineering
CO5	Understand the basic concepts involved in various forms of Matrix decomposition and its application in engineering.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Real and Complex Vector Spaces, Subspaces, Span, Linear Independence,		CO1	2

Dimension.		
Linear Transformations: Linear Transformations, Rank and Nullity, Matrix Representation, Change of Bases, Solvability of linear systems	CO2	3
Inner products, angle, Orthogonal and orthonormal sets, Gram-Schmidt orthogonalization, Orthogonal and orthonormal basis, Orthogonal Complement, QR-factorization, Best approximation and least squares, Riesz representation and adjoint.	CO3	3
Eigenvalues and Eigenvectors, spectral mapping theorem, characteristic polynomial, Cayley-Hamilton Theorem.	CO4	3
Block-diagonalization, Schur triangularization, Diagonalization Theorem, Generalized eigenvectors, Jordan form, Singular value decomposition, Polar decomposition.	CO5	3

4. Text books

i) H. Anton, C. Rorres, Elementary Linear Algebra, 11th Edition, Wiley, New York, 2019, ISBN -978-1118434413.
ii) S. Lang, Linear Algebra, 3rd edition, Springer, 2004, ISBN- 978-0387964126
iii) D W Lewis, Matrix Theory, World Scientific, 1991. ISBN-978-9810239060
iv) G. Strang, Linear algebra and its applications (4th Edition), Thomson Publications, 2006 ISBN- 978-8131501726.

5. Reference Book(s) and Other Required Material

i) K Janich, Linear Algebra, Springer, 1994, ISBN- 978-0387941288.
ii) B Koleman and D Hill, Elementary Linear Algebra, 9th edition, Pearson, ISBN-2007 978-0132296540.

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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
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

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

Mathematics for Machine Learning with Python

Course Code & Course Title:	**MALAXXX, Mathematics for Machine Learning with Python**		
Course Type:	**IE**		
Name of the programme(s):	B.Tech		
L – T – P	**2-0-2**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

"Mathematics for Machine Learning with Python" course is to equip B.Tech. students with a rigorous, application-oriented mathematical foundation tailored for modern computational science, engineering, and machine learning. By integrating advanced topics from linear algebra, matrix theory, multivariable calculus, optimization, probability, and statistics, the course aims to foster not just mathematical fluency but also critical analytical thinking and problem-solving ability—a hallmark of engineering excellence. Students will develop a deep understanding of vector spaces, matrix decompositions, eigenvalues, gradients, and the underpinnings of optimization, all while consistently relating these topics to computational methods and real-world applications via Python-based tools. The curriculum emphasizes building the skills necessary to model, analyze, and solve complex engineering and data-driven problems, connecting abstract mathematical concepts to powerful machine learning techniques like regression, classification, dimensionality reduction, and regularization. By the end of the course, students will be able to apply theoretical knowledge practically, understand and implement core algorithms, critically evaluate results, and lay a strong groundwork for more advanced studies or careers in machine learning, data science, or computational engineering.

2.	**Course Outcomes :**
CO1	Introduction to Python basics
CO2	Fundamental Understanding of Linear Algebra in ML
CO3	Multivariate Calculus and Optimization
CO4	Probability and Statistics with applications
CO5	Applications in ML

3.	Detailed Description of the Course		
Topics		**CO(s) Addressed**	**Duration in weeks**
Theory: Core Python syntax, control flow, functions, data structures. NumPy basics: arrays, indexing, slicing, vectorized operations. Matplotlib: plotting functions, scatter plots. **Lab:** Implement vector/matrix operations in NumPy. Plot transformations of 2D vectors.		CO1	2
Theory: Vectors, vector spaces, basis, dimension, independence. Matrix operations: addition, multiplication, transpose, inverse, rank. Eigenvalues/eigenvectors, diagonalization, spectral theorem. Singular Value Decomposition (SVD).**Lab**: Compute eigenvalues/eigenvectors in NumPy. Visualize eigen directions in 2D. PCA implementation on dataset (e.g., digits/faces).		CO2	3
Theory: Functions of several variables, partial derivatives, gradients, Jacobians, Hessians. Chain rule, quadratic forms. Optimization: gradient descent, learning rate. Convexity & constrained optimization (Lagrange multipliers).**Lab**: Numerical gradient calculation & visualization using automatic differentiation (e.g., PyTorch/JAX), Implement gradient descent for linear regression. Experiment with different learning rates & convergence.		CO3	3
Theory: Axioms of probability, conditional probability, Bayes' theorem. Random variables (discrete/continuous), expectation, variance. Distributions: Bernoulli, Binomial, Poisson, Normal. Maximum Likelihood Estimator (MLE), confidence intervals, hypothesis testing, bias–variance.**Lab**: Simulate random variables & distributions in NumPy. Monte Carlo estimation of probability. Apply MLE to estimate distribution parameters.		CO4	3
Theory: Mathematical framing of ML: regression, classification, loss minimization. Linear regression, logistic regression. Regularization (L1/L2). Introduction to support vector machines (SVM) (conceptual, geometric idea).**Lab**: Build logistic regression classifier with NumPy, Compare with scikit-learn implementation. Mini-project: Dimensionality reduction (PCA) + classification.		CO5	3

4.	Text books

i) Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press,2020 (freely available at mml-book.github.io).

ii) Gilbert Strang, Introduction to Linear Algebra, 5th Edition, MIT Press,2016, ISBN : 978-09802327-7-6

iii) Sheldon Ross, Introduction to Probability and Statistics for Engineers and Scientists, Academic Press, 6th Edition, 2020, ISBN: 978-0128243466

iv) Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press, 1st edition, 2004, ISBN: 978-0521833783

v) Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006, ISBN: 978-0387310732

vi) Jake VanderPlas, Python Data Science Handbook, O'Reilly, 2nd Edition, 2023, ISBN: 978-1098121228

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

i) Trevor Hastie, Robert Tibshirani, Jerome Friedman: The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2nd edition, 2009, ISBN: 978-0387848570

ii) NumPy, SciPy, and scikit-learn official documentation and tutorials.

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

Weightage: Mid semester: 20-30%, Internal Assessment: 10-20%, End semester: 50-60%

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
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):**

Optimization Techniques for Machine Learning

Course Code & Course Title:	**MALA 204 Optimization Techniques for Machine Learning**		
Course Type:	**IE**		
Name of the programme(s):	B.Tech		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**Linear Algebra, Calculus**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this course is to introduce undergraduate students to fundamental optimization techniques widely used in machine learning. Students will learn the basic principles of how machine learning models are trained by minimizing error, and gain practical skills in applying common optimization algorithms.

2.	**Course Outcomes:**
CO1	Understand the basic concepts of optimization, including objective functions, gradients, and the goal of training machine learning models.
CO2	Apply fundamental optimization algorithms like Gradient Descent and its variants to train simple machine learning models.
CO3	Gain practical experience in implementing and using optimization methods with popular programming tools for machine learning.
CO4	Recognize the importance of optimization in various machine learning applications and its impact on model performance.
CO5	Develop an appreciation for the iterative nature of machine learning model training through optimization.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Review of Vector spaces, Subspaces, Eigenvalue Decomposition, Singular Value Decomposition Algorithms and Methods. PSD (Positive Semi-Definite) Matrices and Kernel Functions. Vector Calculus fundamentals.		CO1	3
Convex Functions: Definition, properties, and importance in optimization. First and Second Order Conditions for Optimizations. Identifying Convex and Non-Convex Optimization problems in Machine Learning		CO1	2

Gradient Descent Method. Programming basic optimization problems and their solutions using Gradient Descent. Projected Gradient Descent, Stochastic Gradient Descent (SGD), Proximal Gradient Descent. Training a Neural Network, examples of Projected, Stochastic, Proximal, Accelerated, and Coordinate Descent.	CO2, CO3	4
Newton's Method, Introduction to PyTorch/TensorFlow. Practical Assignments and Projects: Implement Gradient Descent in Python (using NumPy) for a simple linear regression problem. Train a small neural network using a deep learning framework (PyTorch/TensorFlow) and experiment with different built-in optimizers. Analyze the effect of different learning rates on convergence and model performance for a given data set.	CO4, CO 5	4

4.	**Text books**

i) Blum, Avrim; Hopcroft, John; Kannan, Ravindran, Foundations of Data Science, Cambridge University Press, 2020, ISBN- 978-1-108-48506-7

ii) Chong, Edwin K. P.; Żak, Stanisław H., An Introduction to Optimization, Fourth Edition, Wiley-Interscience, 2013. ISBN-978-1-118-27901-4

iii) Strang, Gilbert, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019. ISBN-978-0692196380.

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

i) Boyd, Stephen; Vandenberghe, Lieven, Convex Optimization, Cambridge University Press, 2004. 978-0-521-83378-3.

ii) Murphy, Kevin P., Machine Learning: A Probabilistic Perspective, MIT Press, 2012. 9780262018029

iii) Sra, Suvrit; Nowozin, Sebastian; Wright, Stephen J., Optimization for Machine Learning, MIT Press, 2011. 9780262537766

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

Weightage: Mid semester: 20-30% Internal Assessment: 10-20% End semester: 50-60%

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

List of Indicative Laboratory Experiment (if applicable): NA

Operations Research

Course Code & Course Title:	**MAL 301 - Operations Research**		
Course Type:	**OC**		
Name of the programme(s):	B. Tech. / B. Arch.		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**NIL**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the optimization technique for solving Linear and Nonlinear programming problems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand various methods for solving Linear Programming Problems.
CO2	Familiar with algorithms for solving Transportation problems and the assignment problem
CO3	Will be able to understand the approaches available to solve non-linear problems.
CO4	Will be exposed to understand the methods that are inherent in software packages for solving Optimization problems.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Linear Programming: Formulation of a Linear Programming Problem, Graphical solution, Simplex method (including Big M method and two-phase method), Dual problem, duality theory, dual simplex method, revised simplex method.		CO1, CO4	4
Transportation Problem: existence of solution; degeneracy, MODI method. Assignment Problem: Traveling Salesman Problem.		CO2, CO4	3

Dynamic Programming: Multistage decision process, concept of sub-optimization, principle of optimality, computational procedure in dynamic programming, applications to problems involving discrete variables, continuous variables, and constraints involving equations and inequalities.	CO3, CO4	3
Nonlinear Programming Problem (NLPP): constrained NLPP, Lagrange's multipliers method, convex NLPP, Kuhn-Tucker conditions.	CO3, CO4	3

4.	**Text books**

i) J.C. Pant, Introduction to Optimization: Operations Research, 7th Edition, Jain Brothers, 2008, ISBN: 9788183600767.

ii) Kanti Swarup et. al., Operations Research, Sultan Chand and Co, 2014, ISBN: 8180549097

iii) H.A.Taha: Operations Research, An Introduction, 10th edition, PHI,2019, ISBN: 9352865278.

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

i) Kambo: Mathematical Programming Techniques, revised Edition, East-West Publishers, New Delhi, 2008, ISBN: 8185336474

ii) S.S. Rao, Engineering Optimization: Theory & Practice, 3rd Edition, New Age International (p) Limited, 2013, ISBN: 8122427235.

iii) H.M.Wagner : Principles of Operations Research, 2nd Edition, Prentice Hall of India, New Delhi, 1980, ISBN: 8120301625

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1															

CO 2															
CO 3															
CO 4															
CO 5															

High - 3; Medium – 2; Low – 1;

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

Fractional Calculus

Course Code & Course Title:	**MAL 302 - Fractional Calculus**		
Course Type:	**OC**		
Name of the programme(s):	B. Tech. / B. Arch.		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**NIL**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The main objective of this course is to introduce the fractional-order calculus and its applications in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understanding Gamma Function, Beta Function, Hypergeometric Functions.
CO2	Learning of Fractional Derivatives and Integrals.
CO3	Will be able to understand the Existence and Uniqueness of Linear Fractional Differential Equations.
CO4	Will be exposed to understand the Laplace Transform Method, The Mellin Transform Method, Power Series Method for solutions of fractional differential equations .

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Functions used in Fractional Calculus: Gamma Function, Beta Function, Mittag-Leffler Function, Wright Function, Hypergeometric Functions.		**CO1**	3
Fractional Derivatives and Integrals. Grünwald-Letnikov Fractional Derivatives, Riemann- Liouville Fractional Derivative, Riemann-Liouville Fractional Integral, Caputo's Fractional Derivative, Fractional Integral Equations (First and Second kind), Geometric and Physical		**CO2**	4

Interpretation of Fractional Integration and Fractional Differentiation. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives and Fractional Integrals. Fourier Transforms of Fractional Derivatives and Fractional Integrals.		
Linear Fractional Differential Equations. Fractional Differential Equation of a General Form, Existence and Uniqueness Theorem as a Method of Solution, Dependence of a Solution on Initial Conditions.	**CO3**	3
Methods for the Solution of Fractional-order Equations: The Laplace Transform Method, The Mellin Transform Method, Power Series Method. Babenko's Symbolic Calculus Method, Fractional Green's function.	**CO4**	3

4.	**Text books**

i) S. Das, Functional Fractional Calculus, latest Edition, Springer Berlin, 2011, ISBN: 9783642205453.

ii) I. Podlubny, Fractional Differential Equations, 1st Edition, Academic Press, San Diego, 1999, ISBN: 9780125588409.

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

i) A.A Kilbas, H.M. Srivastava, and J.J. Trujillo, J.J, Theory and Applications of Fractional Differential Equations, 1st Edition, Elsevier, Amsterdam, ISBN: 9780444518323.

ii) Oldham KB & Spanier J. The fractional calculus. New York: Academic Press, 2006, ISBN: 0486450015

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3

CO 1															
CO 2															
CO 3															
CO 4															
CO 5															

High - 3; Medium – 2; Low – 1;

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

Calculus of Variations and Integral Equations

Course Code & Course Title:	**MAL 303 - Calculus of Variations and Integral Equations**		
Course Type:	**OC**		
Name of the programme(s):	B. Tech. / B. Arch.		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**NIL**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the basic importance of special functions, calculus of variations, and integral equations.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand Frobenius method, Legendre equation, Bessel equation, Sturm – Liouville Problems.
CO2	Familiar with Variation and its properties, variational problems in parametric form, applications, Direct methods – Ritz method, Kantorovich's method.
CO3	Will be able to understand the Volterra Integral Equations, Solution of integral equations by Resolvent Kernel, Method of successive approximations, Solution using Laplace transformation.
CO4	Will be exposed to understand the Fredholm equations of the second kind, Integral equations with degenerate kernels, Characteristic numbers and eigen functions, symmetric equations.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Special Functions: Series solutions, Frobenius method, Legendre equation, Bessel equation, Legendre Polynomials, Bessel function of first kind, Sturm – Liouville Problems.		**CO1**	3
Calculus of Variations: Variation and its properties, Euler's equation,		**CO2**	4

Functional dependent on higher order derivatives, functional dependent of the functions of several independent variables, variational problems in parametric form, applications, variational problems with moving boundaries, variational problems involving a conditional extremum, Direct methods – Ritz method, Kantorovich's method.		
Integral Equations: Volterra Integral Equations: Basic concepts, Relationship between linear differential equations and Volterra integral equations, Resolvent Kernel of Volterra Integral equation, Solution of integral equations by Resolvent Kernel, Method of successive approximations, Convolution type equations, Solution of integral differential equations with the aid of Laplace transformation.	**CO3**	3
Fredholm Integral equations: Fredholm equations of the second kind, Fundamentals - Iterated Kernels, Constructing the resolvent Kernel with the aid of iterated Kernels, Integral equations with degenerate kernels, Characteristic numbers and eigen functions, Solution of homogeneous integral equations with degenerate kernel, Non-homogeneous symmetric equations, Fredholm alternative	**CO4**	3

4.	Text books

i) I. Sneddon, The Use of Integral Transforms, Tata McGraw Hill, 1974, ISBN: 0070594368.

ii) Hildebrand, Methods of Applied Mathematics, 2nd edition, Dover Publications, 1992, ISBN: 9780486670027.

iii) L. Elsgolts, Differential equations and calculus of variations, MIR publisher, Moscow, 2003, ISBN: 1410210677.

5.	Reference Book(s) and Other Required Material

i) Krasnov, Problems and Exercises in Integral Equations, Mir Publication, 1971, ISBN: 0714704059.

ii) Ram P Kanwal, Linear Integral Equations, 2nd Edition, Academic Press, 2014, ISBN: 1461268931.

iii) F.G.Tricomi, Integral Equations, Dover Publications, 1985, ISBN: 9780486158303.

iv) R. V. Churchill and J. W. Brown, Fourier series and boundary value problems, 7th Edition, McGraw-Hill. 2006, ISBN: 0073051934.

v) Jain, R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics, 5th Edition, Narosa Publishers, 2005, ISBN: 8184875606.

vi) E. Kreyszig, Advanced engineering mathematics, 8th Edition, John Wiley, 1999, ISBN: 0471154962

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1															
CO 2															
CO 3															
CO 4															

High - 3; Medium – 2; Low – 1;

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

Financial Mathematics

Course Code & Course Title:	**MAL 304 - Financial Mathematics**		
Course Type:	**OC**		
Name of the programme(s):	B. Tech. / B. Arch.		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	Probability and Statistics for Engineering (MAL 205) and Operations Research (MAL 301)		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The main objective of this course is to introduce financial mathematics and its applications to marketing.

ii)	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Grasp basic terminologies of financial mathematics like, Financial assets, securities, bonds, risk Stocks, Short selling, Portfolio, Options, Forward, Put and Call etc. and its use in Finance.
CO2	Understand the Mathematics of basic theory of option Pricing, Single and Multi-period binomial pricing model, Binomial Lattice model, Black-Scholes formula and its application in predicting the price of the European and American call and put option.
CO3	Know about risk and return of an asset, Capital asset pricing model, Theoretical and computational Issues of Markowitz model of portfolio Optimization.
CO4	Understand the concept of Stochastic Processes, Stochastic Calculus, Filtration and Martingales and its application in predicting the price of the European and American call and put option.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Some Basic definitions and terminology.		**CO1, CO2**	1
Basic Theory of Option Pricing: Single and Multi-Period Binomial Pricing Models, Cox-Ross-Rubinstein (CRR) Model, Black-Scholes		**CO2**	2

Formula for Option Pricing as a Limit of CRR Model.		
Brownian and Geometric Brownian Motion, Theory of Martingales. Stochastic Calculus, Stochastic Differential Equations, Ito's Formula to Solve SDE's. Applications of Stochastic Calculus in Option Pricing.	**CO4**	4
Mean-Variance Portfolio Theory: Markowitz Model of Portfolio Optimization and Capital Asset Pricing Model (CAPM). Limitations of Markowitz Model and New Measures of Risk.	**CO3**	3
Interest Rates and Interest Rate Derivatives: Binomial Lattice Model, Vasicek, Hull, and White Models for Bond Pricing.	**CO3**	3

4.	**Text books**

i) D. G. Luenberger: Investment Science, 2nd Edition, Oxford University Press, 2013, ISBN: 0199740089.

ii) M. Capińsky and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Edition, Springer, 2010, ISBN: 9780857290816.

iii) Thomas Mikosch: Elementary Stochastic Calculus with Finance in view, World Scientific, 1998, ISBN: 9810235437.

iv) Suresh Chandra, S. Dharmaraja, Aparna Mehra, R. Khemchandani: Financial Mathematics: An Introduction, Narosa Publishing House, 2012, ISBN: 1842656546.

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

i) S. E. Shreve: Stochastic Calculus for Finance, Vol. I, Springer, 2005, ISBN: 0387249680.

ii) S. E. Shreve: Stochastic Calculus for Finance, Vol. II, Springer, 2008, ISBN: 0387401016.

iii) Sean Dineen: Probability Theory in Finance: A Mathematical Guide to the Black-Scholes Formula, Indian edition, American Mathematical Society, 2005, ISBN: 0821839519.

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1															
CO 2															
CO 3															
CO 4															

High - 3; Medium – 2; Low – 1;

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

Wavelet Analysis

Course Code & Course Title:	**MAL 305 - Wavelet Analysis**		
Course Type:	**OC**		
Name of the programme(s):	B. Tech. / B. Arch.		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**NIL**		
Course Equivalence: Course Code(s) & Name(s)			

v)	**Course Objective:** The main objective of this course is to introduce the wavelet Analysis.

1.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the wavelet transform – Haar wavelet, Haar functions and Haar series, construction of standard Brownian motion.
CO2	Learn about Orthogonal systems, Meyer wavelets, explicit representation of compact wavelets, Daubechies recipe, Hernandez-Weiss recipe.
CO3	Able to grasp the convergence properties of wavelet expansions, almost everywhere convergence, convergence at a preassigned point, general formulation of MRA and wavelets in R^d.

2.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Heuristic treatment of the wavelet transforms – wavelet transform – Haar wavelet expansion: Haar functions and Haar series, Haar sums and Dyadic projections, completeness of the Haar functions, Haar series in C_0 and L_p spaces, pointwise convergence of Haar series, construction of standard Brownian motion,		**CO1**	4
Haar function representation of Brownian motion – Multiresolution analysis: Orthogonal systems, scaling functuions, from scaling function to MRA, Meyer wavelets, from scaling function to orthonormal wavelet – Wavelets with compact support: from scaling filter to scaling function, explicit representation of compact wavelets, Daubechies recipe,		**CO2**	5

Hernandez-Weiss recipe,		
Smoothness of wavelets - convergence properties of wavelet expansions: wavelet series in L^p spaces, large scale analysis, almost everywhere convergence, convergence at a preassigned point – Wavelets in several variables: tensor product of wavelets, general formulation of MRA and wavelets in R^d, Examples of wavelets in R^d.	**CO3**	4

vi)	**Text books**

i) Mark A. Pinsky, Introduction to Fourier analysis and wavelets, Indian Edition, Orient Blackswan Private Limited - New Delhi, 2012, ISBN: 0821887122.

vii)	**Reference Book(s) and Other Required Material**

i) M.V.Altaisky, Wavewlets: Theory, Applications, Implementation, University Press, 2005, ISBN: 8173715033.

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

ix)	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1															
CO 2															
CO 3															
CO 4															

High - 3; Medium – 2; Low – 1;

x)	**List of Indicative Laboratory Experiment (if applicable):**

Finite Difference methods for Differential equations

Course Code & Course Title:	**MAL401–Finite Difference methods for Differential equations**		
Course Type:	**DC**		
Name of the programme(s):	**M.Tech/B.Arch/B.Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the importance of finite difference methods for solving ordinary and partial differential equations.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Solve the boundary value problems in ordinary differential equations using finite difference methods.
CO2	Understand different types of methods for solving Parabolic, Hyperbolic and Elliptic Partial differential equations.
CO3	Will be exposed to understand the methods which are inherent in software packages for solving various engineering problems.
CO4	Will be exposed to apply these finite difference methods for solving various problems in science and engineering.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Finite difference methods: finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, Quasilinearization, Cubic splines and their application for solving two-point boundary value problems.		**CO1, CO2**	6
Solution of Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for: **Parabolic equations**: Schmidt's two level, multilevel explicit methods, Crank-Nicolson's method; **Hyperbolic Equations**: Explicit methods, implicit methods, one		**CO3, CO4**	7

space dimension, two space dimensions; **Elliptic equations**: Laplace equation, Poisson equation, iterative schemes.		

4.	Text books

i. Dr. Lothar Collatz: The numerical treatment of differential equations, Springer-Verlag, New York 1960. ISBN: 978-3540025115
ii. G.D. Smith: Numerical solution of Partial Differential equations, Finite Difference methods, Oxford University Press, 1985. ISBN: 978-0198596417
iii. K.W. Morton & D.F. Mayers: Numerical solution of Partial differential equations, Cambridge University press. 2005. ISBN: 978-0521607933

5.	Reference Book(s) and Other Required Material

i. M.K. Jain : Numerical solution of Differential equations, Wiley Eastern, New Delhi, 1984. ISBN: 978-0852264324
ii. M.K. Jain, S.R.K. Iyengar & R.K. Jain: Numerical Methods for Scientific & Engineering Computation, New Age International Publishers, 1996. ISBN: 978-8122408409

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Numerical Linear Algebra

Course Code & Course Title:	**MAL 403 – Numerical Linear Algebra**		
Course Type:	**OC**		
Name of the programme(s):	**B.Arch/B.Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the basic importance of Linear Algebra and numerical linear algebra and its applications to science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the vector and matrix norms, deal with the Gauss elimination and LU factorization using Gaussian elimination.
CO2	Deal with the LU factorization methods, Conditioning of linear systems.
CO3	Deal with the iteration methods viz., Gauss Jacobi, Gauss-Seidel, SOR and Conjugate gradient methods.
CO4	Deal with the QR factorization and Singular value decomposition (SVD), find least squares solutions and obtain approximation of eigenvalues of a given square matrix.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Special Matrices, Vector and Matrix Norms, SVD. Floating Point Numbers and Errors. Stability, Conditioning and Accuracy. Gauss Elimination and Linear Systems, LU Factorization using Gaussian Elimination, Stability of Gaussian Elimination, Basic Results on Existence and Uniqueness, Some Applications Giving Rise to Linear Systems of Problems, LU Factorization Methods, Conditioning and Pivoting, Inverses and Determinants.		CO1/ CO2	5
Iterative Methods for Large and Sparse Problems: Gauss Seidal, SOR, Chebyshev Acceleration, Conjugate Gradient Method, Preconditioning.		CO3	4

QR Factorization, SVD, and Least Squares Solutions. Numerical Eigenvalue Problems, Generalized Eigenvalue Problem.	CO4	4

4.	**Text books**

i) B. N. Datta: Numerical Linear Algebra and Applications, Springer, 2008. ISBN: 978-0898716856

ii) G. Allaire and S. M. Kaber: Numerical Linear Algebra, Springer, 2007. ISBN: 978-0387489278

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

i. G. H. Golub and C. F. van Loan: Matrix Computations, Johns Hopkins University Press, 1984. ISBN: 978-0801830112

ii. L. N. Trefethen and D. Bau, III: Numerical Linear Algebra, SIAM, 1997. ISBN: 978-0898713619

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Perturbation Methods

Course Code & Course Title:	**MAL 406– Perturbation Methods**		
Course Type:	**OC**		
Name of the programme(s):	**B.Arch/B.Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the advanced methods to tackle special class of linear and non-linear problems which occur frequently in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To learn and understand classification of singular points of Homogeneous linear equations, Local behaviour at irregular singular points of homogeneous linear equations, Irregular singular point at infinity, Asymptotic Relations, Asymptotic series.
CO2	To learn and understand spontaneous singularities, approximate solutions to higher order nonlinear differential equations, non-linear autonomous systems.
CO3	To learn and understand the application to polynomial equations and initial value problems for differential equations, Asymptotic Matching: Matched asymptotic expansions, application to differential equations.
CO4	To learn and understand boundary layer theory, uniformly valid global approximants to simple boundary value problems, non linear boundary layer problems.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Approximate Solution of Linear Differential equations: Classification of singular points of Homogeneous linear equations, Local behavior near ordinary points of homogeneous linear equations, Local series expansions about regular singular points homogeneous linear equations, Local behavior at irregular singular points of homogeneous linear equations, Irregular singular point at infinity, Local analysis of	CO1	3

Inhomogeneous Linear equations, Asymptotic Relations, Asymptotic series.		
Approximate Solution of Nonlinear Differential equations: Spontaneous Singularities, Approximate solutions of first order non-linear equations, Approximate solutions to Higher order nonlinear differential equations, non-linear autonomous systems.	CO2	3
Perturbation Methods Perturbation theory: elementary introduction, application to polynomial equations and initial value problems for differential equations. Regular and singular perturbation theory: classification of perturbation problems as regular and singular, introductory examples of boundary – layer, WKB and multiple scale problems. Asymptotic Matching: Matched asymptotic expansions, application to differential equations.	CO3	4
Boundary Layer theory Introduction to Boundary – Layer theory: Linear and nonlinear examples. Mathematical Structure of Boundary Layers: Inner, outer and intermediate limits. Higher order boundary layer theory: Uniformly valid global approximants to simple boundary value problems. Distinguished Limits and Boundary layers of thickness $\neq \varepsilon$: illustrative examples Miscellaneous Examples of Linear Boundary Layer problems, Non Linear Boundary Layer problems.	CO4	3

4.	**Text books**

i) Advanced Mathematical methods for Scientists and Engineers by Carl M. Bender & Steven A. Orszag, McGraw Hill International, 1999.

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

i) Perturbation Methods by Ali Hasan Nayfeh, John Wiley & Sons, New York, 2007.

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Statistics & Optimization Techniques

Course Code & Course Title:	**MAL 407– Statistics & Optimization Techniques**		
Course Type:	**OC**		
Name of the programme(s):	**B.Arch/B.Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the advanced methods to tackle special class of linear and non-linear problems which occur frequently in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To learn and understand Sampling Theory & Estimation Theory
CO2	To learn and understand Tests of Hypothesis and Significance
CO3	To learn and understand O. R. Techniques

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Sampling Theory: Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, the sample variance, the sampling distribution of variance. **Estimation Theory:** Point estimate and interval estimates, reliability, confidence interval estimates of population parameters, confidence intervals for means, proportions and variance.		CO1	3
Tests of Hypothesis and Significance: Statistical decisions, tests of hypotheses and significance, Type I and Type II errors, level of significance, one tailed and two tailed tests. Tests involving small samples and large samples, fitting theoretical distributions to sample frequency distribution, The chi-square test for goodness of fit.		CO2	4
O. R. Techniques- Linear Programming: Formulation of linear programming problem, Graphical solution- simplex method (including Big M method and two phase method), dual problem- duality theory, dual simplex method, revised simplex method.		CO3	6

Transportation problem: Existence of solution-degeneracy- MODI method; Assignment problem- traveling salesman problem **Nonlinear programming problem (NLPP):** Constrained NLPP, Lagrange's multipliers method – convex NLPP, Kuhn-Tucker conditions.		

4.	**Text books**

i. M.R. Speigel: Probability and Statistics, McGraw-Hill, 1995. **ISBN: 978-0070602854**

ii. H.A. Taha : Operation Research Prentice Hall of India Pvt. Ltd, 1998**. ISBN: 978-0130113917**

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

i. J.C. Pant: Introduction to Optimization: Operations Research, Jain Brothers, New Delhi, 2004. **ISBN: 978-8186321409**

ii. Miller and Freund: Probability and Statistics for Engineers, Economy Edition, PHI, 8th Edition, 2011. **ISBN: 978-8120342200**

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

Mid Sem: 30 Marks

Internal: 20 Marks

End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Statistical Analysis & Queuing Theory

Course Code & Course Title:	**MAL408 - Statistical Analysis & Queuing Theory**		
Course Type:	**OC**		
Name of the programme(s):	**B.Arch/B.Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the importance of statistical analysis. It also focuses on waiting time models.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Be exposed to the importance of statistical analysis such as estimation, testing of hypothesis, regression.
CO2	Be aware of waiting time models with the use of Bernoulli/Poisson/Renewal process.
CO3	Be able to use Markov chains for analysis of queues and birth-death process.
CO4	Be able to apply queuing theory models to real life situations.
CO5	Be able to use curve fitting methods.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Testing of Hypotheses: Neyman Pearson theory of testing of Hypotheses: Some fundamental notions of hypotheses testing, Neyman Pearson lemma, unbiased and invariant tests, generalized likelihood ratio tests, Chi – Square test, t – tests, F – tests, Bayes and minimax procedures, methods of finding confidence intervals, unbiased and equivariant confidence intervals.		**CO1**	2
Stochastic Processes: Introduction, classification of stochastic processes, the Bernoulli process, the Poisson process, Renewal process, availability analysis, random incidence, renewal model of program behavior.		**CO2**	2
Discrete-Parameter Markov Chains: Introduction, computation of n-		**CO3**	3

step transition probabilities, state classification and limiting distributions, distribution of times between state changes, irreducible finite change with A periodic states, the M/G/1 Queuing system, discrete parameter Birth-Death processes, finite Markov chains with absorbing states.		
Continuous – Parameter Markov Chains: Introduction, the Birth and death process, other special cases of Birth –death Model, non-Birth-Death processes, Markov chains with absorbing states.	**CO4**	2
Networks of Queues: Introduction, open queuing networks, closed queuing networks, non-exponential service-time distributions and multiple job types, Non – product- Form Networks.	**CO5**	2
Regression, correlation and Analysis of Variance: Introduction, Least squares curve fitting, the coefficient of determination, confidence intervals in linear regression, correlation analysis, simple non-linear regression, higher dimensional least squares fit, analysis of variance.	**CO1**	2

4.	**Text books**

i) Vijay K. Rohatgi & A.K. Md. Ehsanes Saleh: An Introduction to Probability and statistics, John Wiley & Sons Inc., New York, 1976. ISBN: 978-0471731351

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

i) Kishor S. Trivedi: Probability & Statistics with reliability, Queuing and computer Science applications, PHI private Ltd, 2009. ISBN: 978-8120338616

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Application of Operational Research Techniques in Construction Management

Course Code & Course Title:	**MAL409 - Application of Operational Research Techniques in Construction Management**		
Course Type:	**OC**		
Name of the programme(s):	**B.Arch/B.Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the importance of operational research to solve problems related to construction management.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Formulate Linear programming problem of the real life problem occurring in the field of manufacturing and logistics, production planning, Man power problem etc. Formulate Mathematical model and finding optimal solution of Transportation problem, Assignment Problem, Travelling Salesman Problem.
CO2	Know about Dynamic Programming method and its stage wise solution procedure to solve a problem stage wise.
CO3	Understand basic of Inventory Management, Sequencing, Game Theory and its real line application in the field of construction management.
CO4	Deal with Simulation as applied to construction. Modifications and improvements on CPM/PERT techniques applications to construction management.
CO5	Formulate Linear programming problem of the real life problem occurring in the field of manufacturing and logistics, production planning, Man power problem etc. Formulate Mathematical model and finding optimal solution of Transportation problem, Assignment Problem, Travelling Salesman Problem.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Introduction to linear programming, transportation and assignment problems. Dynamic programming waiting line models.		**CO1/CO2**	7

Inventory Management, Sequencing, Decision theory, Game theory, Simulation as applied to construction. Modifications and improvements on CPM/PERT techniques applications to construction management.	**CO3/CO4/CO5**	6

4.	**Text books**

i) N. D. Vohra: Quantitative Techniques in Management, The Mc. Graw Hill Companies. ISBN: 978-0070146730

ii) J.C. Pant, Introduction to Optimization: Operations Research Jain Brothers, New Delhi. ISBN: 978-8186321409

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

i) H.M. Wagner: Principles of Operations Research, Prentice Hall of India, New Delhi. ISBN: 978-8120301627

ii) Kambo: Mathematical Programming Techniques, East-West Publishers, New Delhi. ISBN: 978-8185938974

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

Introduction to Finite Element Method

Course Code & Course Title:	**MAL 410 – Introduction to Finite Element Method**		
Course Type:	**OC**		
Name of the programme(s):	**B.Arch/B.Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the importance of finite element methods to tackle the problems of science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Introduction to Calculus of Variations.
CO2	To learn and understand Global and local finite element models in one dimension - derivation of finite element equation.
CO3	To learn and understand Finite Element Method: Rayleigh-Ritz minimization - weighted residuals - Galerkin method applied to boundary value problems.
CO4	To learn and understand Finite element interpolation, polynomial elements in one dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite elements for rectangular elements - global interpolation functions.
CO5	To learn and understand Local and global forms of finite element equations - boundary conditions - methods of solution for a steady state problem - Newton-Raphson continuation - one dimensional heat and wave equations.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Calculus of Variations.		**CO1**	2
finite element models in one dimension - derivation of finite element equation.		**CO2**	3

Finite Element Method: Rayleigh-Ritz minimization - weighted residuals - Galerkin method applied to boundary value problems.	**CO3**	2
Finite element interpolation - polynomial elements inone dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite elements for rectangular elements - global interpolation functions.	**CO4**	3
Local and global forms of finite element equations - boundary conditions - methods of solution for a steady state problem - Newton-Raphson continuation - one dimensional heat and wave equations.	**CO5**	3

4.	**Text books**

i) J.N. Reddy: An introduction to the Finite Element Method, McGraw Hill, New York, 2006. ISBN: 978-0072466850.

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

i) T.J. Chung: Finite element analysis in Fluid Dynamics, McGraw Hill Inc, 1978. ISBN: 978-0070108301

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

High - 3; Medium – 2; Low – 1;

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

M.Tech Courses

Applied Linear Algebra

Course Code & Course Title:	**MAL504, Applied Linear Algebra**		
Course Type:	**DE**		
Name of the programme(s):	**M. Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Vector spaces, linear independence, bases and dimension, linear maps and matrices, eigenvalues, invariant subspaces, inner products, norms, orthonormal bases, spectral theorem, isometries.
CO2	Linear Transformations, The Null Space and the Range Space of a Linear Transformation, , The Rank-Nullity-Dimension Theorem.
CO3	Isomorphisms between Vector Spaces, polar and singular value decomposition.
CO4	Operators on real and complex vector spaces, characteristic polynomial, minimal polynomial.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Vector spaces, linear independence, bases and dimension, linear maps and matrices, eigenvalues, invariant subspaces, inner products, norms, orthonormal bases, spectral theorem, isometries.		**CO1**	4
Linear Transformations, The Null Space and the Range Space of a Linear Transformation, , The Rank-Nullity-Dimension Theorem.		**CO2**	3
Isomorphisms between Vector Spaces, polar and singular value decomposition.		**CO3**	3

Operators on real and complex vector spaces, characteristic polynomial, minimal polynomial	**CO4**	3

4.	**Text books**

i) N Herstein: Topics in Algebra, 2nd Edition, John-Wiley.
ii) K. Hoffman and R. Kunze, Linear Algebra, Pearson Education (India).
iii) M. Artin: Algebra, 2nd Edition, Prentice Hall of India, 2011, ISBN 0132413779, 9780132413770.

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

i) S. Kumeresan: Linear Algebra: A Geometric Approach, Prentice Hall of India, Print Book ISBN : 9788120316287
ii) S. Lang: Linear Algebra, 3rd Edition, Springer Undergraduate Texts in Mathematics, ISBN 0-387 -96412-6.

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

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

Mathematical Elements for Engineers

Course Code & Course Title:	**MAL505, Mathematical Elements for Engineers**		
Course Type:	**DC**		
Name of the programme(s):	M. Tech		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the basic importance of linear algebra and numerical techniques to solve scientific problems and provide advanced knowledge of applied mathematics.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the basic importance of linear algebra and numerical techniques to solve scientific problems and improve ability to think logically, analytically and abstractly.
CO2	Implement the numerical techniques to determine the approximate solution of integration.
CO3	Solve various initial and boundary value problems in ordinary and partial differential equations arise in the engineering problems by applying the finite difference methods.
CO4	Study the changes in the physical world and use the techniques to formulate and solve physical problems mathematically.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Linear Algebra & Matrices: Linear Vector Spaces, Linear dependence, basis and dimensions, Four fundamental subspaces, Linear transformations, Transformation from one linear space to another, Inner product space and applications, Eigen values and Eigenvectors, diagonalization, complex matrices, similarity transformations, matrix norms & condition number, iterative methods for solving $AX = b$.		CO1	4
Numerical Techniques: Review of the topics in elementary numerical analysis, Basic Principles, Construction of approximate integration formulae using		CO2	3

method of undetermined weights & nodes, Gauss-Legendre formula, Gauss Chebyshev formula, Gauss-Hermite formula, Errors in numerical integration.		
Finite Difference Methods: Approximation of derivatives (Ordinary & Partial) in terms of pivotal values: Application to solve 1.Boundary value problems in ordinary differential equations 2.Boundary value problems in partial differential equations: Laplace equation, one-dimensional heat equation and one-dimensional wave equation.	CO3	3
Introduction to Mathematical Modelling: Study of cases of modelling through Linear equations and differential equations.	CO4	3

4. Text books

xiii) Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition, 2008, ISBN 9971-51-283-1.

xiv) G.D. Smith: Numerical solution of Partial Differential equations, Finite Difference methods, Oxford University Press, 1985, ISBN 0-19-859650-2, ISBN 0-19-859641-3.

5. Reference Book(s) and Other Required Material

i) G. Strang, Linear algebra and its applications, Thomson Publications, 4th Edition, 2006, ISBN-13 :978-0534422004, ISBN-10: 0534422004.

ii) M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 5th Edition, 2008, ISBN: 9788122420012.

iii) R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Pub House, 3rd Edition, 2008, ISBN: 9788173197307.

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

Mid Sem: 30 Marks

Internal: 20 Marks

End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

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

Statistical Methods for Urban Planning

Course Code & Course Title:	**MAL 506, Statistical Methods for Urban Planning**		
Course Type:	**DC**		
Name of the programme(s):	**M. Tech**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

The objective of this subject is to expose student to understand the importance of statistical methods for urban planning.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Introduction, scope and methods of statistics, frequency distribution, measures of location, dispersion and skewness.
CO2	Correlation & regression analysis, least square method – curve fitting.
CO3	Theory of probability: random variables, some probability distributions – Binomial, Poisson, Normal. Sampling Theory: Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, the sample variance, the sampling distribution of variance.
CO4	Estimation Theory: Point estimate and interval estimates, reliability, confidence interval estimates of population parameters, confidence intervals for means, proportions and variance.
CO5	Tests of Hypothesis and Significance: Statistical decisions, tests of hypotheses and significance, Type I and Type II errors, level of significance, one tailed and two tailed tests. Tests involving small samples and large samples, fitting theoretical distributions to sample frequency distribution, The chi-square test for goodness of fit.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Introduction, scope and methods of statistics, frequency distribution, measures of location, dispersion and skewness.		CO1	2

Correlation & regression analysis, least square method – curve fitting.	CO2	2
Theory of probability: random variables, some probability distributions – Binomial, Poisson, Normal. Sampling Theory: Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, the sample variance, the sampling distribution of variance.	CO3	3
Estimation Theory: Point estimate and interval estimates, reliability, confidence interval estimates of population parameters, confidence intervals for means, proportions and variance.	CO4	3
Tests of Hypothesis and Significance: Statistical decisions, tests of hypotheses and significance, Type I and Type II errors, level of significance, one tailed and two tailed tests. Tests involving small samples and large samples, fitting theoretical distributions to sample frequency distribution, The chi-square test for goodness of fit.	CO5	3

4. Text books

i) Kishor S. Trivedi: Probability & Statistics with reliability, Queuing and computer Science applications, PHI private Ltd, 2009,
ii) M.R. Speigel: Probability and Statistics, McGraw-Hill, 1995.

5. Reference Book(s) and Other Required Material

i) S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Khanna Publishers, New Delhi, 1989.
ii) V.K. Rohatgi and A.K.M.E Saleh: An Introduction to Probability and Statistics, 3rd Edition, John Wiley & Sons, 2015, ISBN: 978-1118799642

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

Mid Sem: 30 Marks
Internal: 20 Marks
End Sem: 50 Marks

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															
CO2															
CO3															
CO4															
CO5															

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