SHRI GURU RAM RAI UNIVERSITY

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PROPOSED CURRICULUM AND SYLLABI
(NEP-2020, UGCF – 2022)

For

FIRST THREE YEARS OF UNDER-GRADUATE (UG) MULTIDISCIPLINARY PROGRAMME

OR

B.Sc. (Honors with Research) in Mathematics

DEPARTMENT OF MATHEMATICS

SCHOOL OF BASIC AND APPLIED SCIENCES
S.G.R.R UNIVERSITY, DEHRADUN-248001, UTTARAKHAND

AS PER GUIDELINES OF COMMON MINIMUM SYLLABUS BY UTTARAKHAND GOVERNMENT ACCORDING TO NATIONAL EDUCATION POLICY-2020
(W.E.F. ACADEMIC SESSION 2023-24)

MEMBER OF BOARD OF STUDIES

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SCHOOL OF BASIC AND SCIENCE
SHRI GURU RAM RAI UNIVERSITY
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DEPARTMENT OF MATHEMATICS,
SCHOOL OF BASIC AND APPLIED SCIENCES,
S.G.R.R. UNIVERSITY, DEHRADUN-248001, UTTARAKHAND

Structure of UG Multidisciplinary Programme
(with Three Core disciplines)

1. Introduction to UG Multidisciplinary Degree Programme with Mathematics

As per the recommendations of the Undergraduate Curriculum Framework 2022 (UGCF 2022), the undergraduate degree course in Multidisciplinary Programme with mathematics is a six/ eight semester course spread over three/ four academic years. The teaching – learning process is student-centric and it involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. Besides the Discipline Specific
Core(DSC) courses, a student can opt courses from the syllabus comprising of Discipline Specific Electives(DSEs), Generic Electives(GEs), Skill Enhancement Courses(SECs), Ability Enhancement courses(AECs) and Value Addition Courses(VACs). Thereby, bringing out the multidisciplinary approach and adherence to innovative ways within the curriculum framework. Moreover, it allows a student maximum flexibility in pursuing his/her studies at the undergraduate level to the extent of having the liberty to eventually design the degree with multiple exit options depending upon the needs and aspirations of the student in terms of his/her goals of life, without compromising on the teaching learning, both in qualitative and quantitative terms. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.

2. Course Type

Discipline Specific Core Courses (DSCC)
Discipline Specific Elective Courses (DSEC)
General Electives Courses (GEC)
Ability Enhancement Courses (AEC)
Skill Enhancement Elective Courses (SEEC)
IAPC: Internship/Apprenticeship / Project/ Community Outreach
VAC: Value Addition Course

3. Courses of Study:

Courses of the study indicate pursuance of study in a particular discipline. Every discipline shall offer four categories of courses of study, viz. Discipline Specific Core (DSC) courses, Discipline Specific Electives (DSEs), Skill Enhancement Courses (SECs) and Generic Electives (GEs). Besides these four courses, a student will select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the University.

3.1) **Discipline Specific Core (DSC):** Discipline Specific Core is a course of study, which should be pursued by a student as a mandatory requirement of his/ her programme of study. In Bachelor of Science (Hons.) Mathematics programme, DSCs are the core credit courses of Mathematics which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020.

3.2) **Discipline Specific Elective (DSE):** The Discipline Specific Electives (DSEs) are a pool of credit courses of Mathematics

from which a student will choose to study based on his/ her interest.

3.3) **Generic Elective (GE):** Generic Electives is a pool of courses offered by various disciplines of study (excluding the GEs offered by the parent discipline) which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond his/ her discipline specific course(s) of study, such DSEs shall be treated as GEs for that student.

3.4) **Ability Enhancement course (AEC):** AEC courses are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are based on Language and Literature, and Environmental Science which are mandatory for all disciplines.

3.5) **Skill Enhancement Course (SEC):** SECs are skill-based courses in all disciplines and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction.

3.6) **Value Addition Course (VAC):** VACs are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural and constitutional values; promote critical thinking, Indian knowledge systems, scientific temperament, communication skills, creative writing, presentation skills, sports and physical education and team work which will help in all round development of students.

3.7) **Internship/Apprenticeship / Project/ Community Outreach (IAPC) :Students can choose IAPC as an optional with SEC.**

4. Programme Duration and Exit Options:

The minimum credit to be earned by a student per semester is 22 credits. The mandatory number of credits which have to be secured for the purpose of award of Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Multidisciplinary Programme with Mathematics are listed in the following Table 1.

Table 1: Qualification Type and Credit Requirements

S. No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award
1.	Undergraduate Certificate in Sciences (with Three Core disciplines)	After successful completion of Semester II	44
2.	Undergraduate Diploma in Science	After successful completion of Semester IV	88
3.	Bachelor of Science	After successful completion of Semester VI	132
4.	Bachelor of Science (Honours with Research) in Mathematics(Major) and Discipline - 2(Minor)	After successful completion of Semester VIII with minimum 28 GE credits in Discipline- 2 (Minor)	176

Major Discipline (Mathematics): A student pursuing four-year undergraduate programme in Mathematics (Core course) shall be awarded B.Sc. Honors degree
with Major in Mathematics on completion of VIII Semester, if he/she secures in Mathematics at least 50% of the total credits i.e., at least 88 credits in Mathematics
out of the total of 176 credits. He/she shall study 20 DSCs and at least 2 DSEs of Mathematics in eight semesters

Minor Discipline (Discipline - 2): A student of B.Sc. (Hons.) in Mathematics may be awarded Minor in a discipline, other than Mathematics, on completion of VIII Semester, if he/she earns minimum 28 credits from seven GE courses of that discipline.

Combinations with other two core disciplines: Dept of Mathematics offer following combinations with core Multidisciplinary/interdisciplinary streams
PCM, PMG, PMS, PMD
P-Physics, C-Chemistry, M-Mathematics, S-Statistics, D-Defense, G-Geology

Note: It is advice to students, choose any one of the above combination to study with core discipline Mathematics.

Table 2: Structure of Undergraduate Programme in Mathematics under UGCF – 2022

Sem.	Discipline Specific Core Courses (DSC)		Discipline Specific Elective Courses (DSEC)/Generic Elective Courses (GEC)		Ability Enhancement Course (AEC)		Skill Enhancement Course(SEC)/ (Internship/Apprenticeship / Project/ Community Outreach) (IAPC)/ (Project/ Dissertation)		Value Addition Course (VAC)		Total Credits
	Courses distribution (Theory or Theory + Practical)	Credits (4 or 3+1)	Courses distribution (Theory or Theory + Practical)	Credits (4 or 3+1)	Courses distribution (Theory or Theory + Practical)	Credits (2)	Courses distribution (Theory or Theory + Practical)	Credits (2)		Credits (2)	22
I	DSC-A1	4	GE-1	4	AEC-1	2	SEC-1	2	VAC-1	2	22
	DSC-B1	4									
	DSC-C1	4									
II	DSC-A2	4	GE-2	4	AEC-2	2	SEC-2	2	VAC-2	2	22
	DSC-B2	4									
	DSC-C2	4									
III	DSC-A3	4	DSE1/GE-3	4	AEC-3	2	SEC-3 / IAPC-1	2	VAC-3	2	22
	DSC-B3	4									
	DSC-C3	4									
IV	DSC-A4	4	DSE2 / GE-4	4	AEC-4	2	SEC-4 / IAPC-2	2	VAC-4	2	22
	DSC-B4	4									
	DSC-C4	4									
V	DSC-A5	4	One DSE-3 and One GE-5	4+4			SEC-5 / IAPC-3	2			22
	DSC-B5	4									
	DSC-C5	4									
VI	DSC-A6	4	One DSE-4 and One GE-6	4+4			SEC-6 / IAPC-4	2			22
	DSC-B6	4									
	DSC-C6	4									
VII	DSC-7	4	DSE-5 /GE-7	4			Dissertation on Major or Dissertation on Minor or Academic Project/Entrepreneurship	6			22
			DSE-6 /GE-8	4							
			DSE-7/GE-9	4							
VIII	DSC-8	4	DSE-8/GE-10	4			Dissertation on Major or Dissertation on Minor or Academic Project/Entrepreneurship	6			22
			DSE-9/GE-11	4							
			DSE-10/GE-12	4							

5.1 Semester-wise Distribution of Discipline Specific Core (DSC) Courses:
A student will study three Discipline Specific Core Courses each in Semesters I to VI and one core course each in semesters VII and VIII. The semester wise distribution of DSC courses over eight semesters is listed in Table 3

Table 3: Semester-wise Distribution of Discipline Specific Core (DSC) Courses (Basket I)

	Discipline Specific Core Courses (4 Credits each)			Contact Hours			Credit
S. No	**Semester**	**Course Code**	**Name Of The Course**	**L**	**T**	**P**	**C**
1.	I	MATDC101	Differential Calculus	3	1	0	4
2.	II	MATDC201	Abstract Algebra	3	1	0	4
3.	III	MATDC301	ODE & PDE-I	3	1	0	4
4.	IV	MATDC401	Real Analysis	3	1	0	4
5.	V	MATDC501	Linear Algebra	3	1	0	4
6.	VI	MATDC601	Complex Analysis-I	3	1	0	4
7.	VII	MATDC701	ODE & PDE –II	3	1	0	4
8.	VIII	MATDC801	Complex Analysis II	3	1	0	4

5.2 Details of Discipline Specific Elective Courses (DSEC):
The Discipline Specific Electives (DSEs) are a pool of credit courses of Mathematics from which a student will choose to study based on his/ her interest. A student of Bachelor of Science (Hons.) Mathematics gets an option of choosing one DSE of Mathematics in each of the semesters III to VI, while the student has an option of choosing a maximum of three DSEC courses of Mathematics in semesters VII and VIII. The semester wise distribution of DSEC courses over eight semesters is listed in Table 4.

Table 4: Semester-wise Distribution of Discipline Specific Elective Courses (Basket II)

	Discipline Specific Elective Courses (4 Credits each)			Contact Hours			credit
S. No	Semester	Course Code	Name of the Course	L	T	P	C
1.	V	MATDE501	Theory of Equations	3	1	0	4
2.	VI	MATDE601	Matrices	3	1	0	4
3.	VII	MATDE701	Analytical Geometry	3	1	0	4
4.	VII	MATDE702	Transportation and Game theory	3	1	0	4
5	VII	MATDE703	Fundamentals of Differential Geometry	3	1	0	4
6	VII	MATDE704	Statics	3	1	0	4
7	VII	MATDE705	Number Theory	3	1	0	4
8	VIII	MATDE801	Discrete Mathematics	3	1	0	4
9	VIII	MATDE802	Mathematical Statistics	3	1	0	4
10	VIII	MATDE803	Dynamics	3	1	0	4
11	VIII	MATDE804	Numerical Analysis	3	1	0	4
12	VIII	MATDE805	Multivariate Calculus	3	1	0	4

Note: In addition to the above proposed courses, students may select courses from the Swayam.org as MOOCs courses upto the permissible limit and course must be 4 credits.

5.3 Details of Skill Enhancement Courses (SEC):

To enhance the skills required for advanced studies, research and employability of students various Skill Enhancement Courses will be offered to students as listed in Table 5.

Table 5: Semester-wise Distribution and Details of Skill Enhancement Courses (SEC) (Basket III)

	Skill Enhancement Courses (2 Credits each)			Contact Hours			credit
S. No	Semester	Course Code	Name of The Course	L	T	P	C
1.	I	MATSC 101	Bio Mathematics	2	0	0	2
2.	II	MATSC 201	Laplace transforms	2	0	0	2
3.	III	MATSC 301	Elementary Algebra & Trigonometry	2	0	0	2
4.	IV	MATSC 401	Numerical Methods for ODE	2	0	0	2
5	V	MATSC 501	Theory of equations	2	0	0	2
6	VI	MATSC 601	Differential geometry	2	0	0	2
7	VII	MATSC 701	Finite Field	2	0	0	2
8	VIII	MATSC 801	Measure and integration	2	0	0	2

Table 6: Semester-wise Distribution and Details of Internship/Apprenticeship/Project/Community Outreach (IAPC) (Basket IV)

1	III	MATI301	Internship-I	0	0	0	2
2	III	MATA301	Apprenticeship-I	0	0	0	2
3	III	MATP301	Project-I	0	0	0	2
4	III	MATCO301	Community Outreach-I	0	0	0	2
5	IV	MATI401	Internship-II	0	0	0	2
6	IV	MATA401	Apprenticeship-II	0	0	0	2
7	IV	MATP401	Project-II	0	0	0	2
8	IV	MATCO401	Community Outreach-II	0	0	0	2
9	V	MATI501	Internship-III	0	0	0	2
10	V	MATA501	Apprenticeship-III	0	0	0	2
11	V	MATP501	Project-III	0	0	0	2
12	V	MATCO501	Community Outreach-III	0	0	0	2
13	VI	MATI601	Internship-IV	0	0	0	2
14	VI	MATA3601	Apprenticeship-IV	0	0	0	2
15	VI	MATP601	Project-IV	0	0	0	2
16	VI	MATCO601	Community Outreach-IV	0	0	0	2

Table 7: (Project/ Dissertation) (Basket V)

1	VII	MATD701	Dissertation on Major-I	0	0	0	6
2	VII	MATD702	Dissertation on Minor-I	0	0	0	6
3	VII	MATAP703/ MATEP704	Academic Project-I/Entrepreneurship-I	0	0	0	6
4	VIII	MATD801	Dissertation on Major-II	0	0	0	6
5	VIII	MATSD802	Dissertation on Minor-II	0	0	0	6
6	VIII	MATAP803/ MATEP804	Academic Project-II/Entrepreneurship-II	0	0	0	6

In addition to the above proposed courses, students may select courses from the **Swayam.org as MOOCs courses** up to the permissible limit.

UG Mathematics

Department of Mathematics

Details of Generic Elective (GE) Courses:
Generic Elective courses provide multidisciplinary or interdisciplinary education to students.

Table 8: Various GE courses offered by the Mathematics Department are listed below (Basket VI)

	Generic Elective (GE) Courses (4 Credits each)			Contact Hours			credit
S. No	Semester	Course Code	Name of The Course	L	T	P	C
1.	I	MATGE101	Basic Applied Mathematics	3	1	0	4
2.	I	MATGE201	Applied Calculus	3	1	0	4
3.	I	MATGE301	Numerical Methods	3	1	0	4
4.	II	MATGE401	Graph Theory	3	1	0	4
5	II	MATGE501	Probability & Statistics	3	1	0	4
6	II	MATGE601	Linear Programming	3	1	0	4
7	III	MATGE701	Advanced Numerical Analysis	3	1	0	4
8	III	MATGE801	Advanced Linear Programming	3	1	0	4

In addition to the above proposed courses, students may select courses from the **Swayam.org as MOOCs courses** up to the permissible limit.

Table 9: Ability Enhancement Course (Basket VII)

Semester	Course Type	Course Code	Course Title	L	T	P	C
I	AEC	AEC-104	Environment Science-I	2	0	0	2
II		AEC-204	Environment Science-II	2	0	0	2
III		AEC-304	English Communication-I	2	0	0	2
IV		AEC-404	English Communication-II	2	0	0	2

1. Subject prerequisites:

1. For Semester I: 12th pass with subjects Physics, Chemistry & Mathematics
2. For Semester II: Passed Semester I with Mathematics
3. For Semester III: Passed Semester II with Certificate Course in Science
4. For Semester IV: Passed Semester III
5. For Semester V: Passed Semester IV with Diploma in Science
6. For Semester VI: Passed Semester V

2. Programme Objectives:

The undergraduate degree course in Mathematics aims to provide:

1) In-depth knowledge in Mathematics through understanding of key mathematical concepts, principles, theories and their applications.
2) inculcate strong interest in learning mathematics,
3) evolve broad and balanced knowledge and understanding of definitions, key concepts, principles and theorems in Mathematics,
4) enable learners/students to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in mathematics,
5) develop in students the ability to apply relevant tools developed in mathematical theory to handle issues and problems in social and natural sciences,
6) provide students with sufficient knowledge and skills that enable them to undertake further studies in mathematics and related disciplines.

3. PROGRAMME OUTCOMES:

The learning outcomes of the undergraduate degree course in Mathematics are as follows:

PO1) Communicate mathematics effectively by written, computational and graphic means.
PO2) Create mathematical ideas from basic axioms
PO3) Gauge the hypothesis, theories, techniques and proofs provisionally.
PO4) Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.
PO5) Identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a plethora of fields and research.
PO6): It is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for the same.
PO7): It is to develop enhanced quantitative skills and pursuing higher mathematics and research as well.
PO8): Students will be able to develop solution-oriented approach towards various issues related to their environment.
PO9): Students will become employable in various govt. and private sectors
PO10): Scientific temper in general and mathematical temper in particular will be developed in students.
PO11): Enhance the ability to develop solution-oriented approach towards various real world problems.
PO12): Evolve in-depth knowledge of various branches of pure and applied mathematics.

4. PROGRAM SPECIFIC OUTCOMES (PSOS)

1. Certificate in Science will give students a basic knowledge of mathematics. Two other major subjects needed for the study of other courses in forthcoming years. It will enable students to join the diploma course (semester III and IV) in any University or College of Higher Education in Uttarakhand
2. Diploma will enable students to join the Bachelor of Science course(semester V and VI) in Any University or College of Higher education in Uttarakhand
3. Upon completion of a degree, students will be eligible for Masters Degree in any of the major subject in any of the higher institutions of India. It will gives students an ability of critical thinking and scientific study of any discipline. Students after getting Bachelors degree will be eligible for all the competitive examinations where graduation is an essential qualification.
4. A very nice and major outcomes NEP term is that, It gives the opportunity end of the every year to get the job and change the University or programme. Hence After successful completion of every year of this programme, students will be able to get the job in various field.

4.1 Programme Specific Outcome OF UG I Year / Certificate course in Science

After completing this certificate course, the student should have:

PSO1): Student should be able to possess recall basic idea about mathematics which can be displayed by them.
PSO2): Student should have adequate exposure to many aspects of mathematical sciences.
PSO3): Student is equipped with problem-solving skills.
PSO4): Student should be able to apply their skills and knowledge in various fields of studies including, science, engineering, commerce and management etc.

4.2 Programme Specific Outcome OF UG II Year / Diploma course in Science

After completing this course, the student will have:

PSO1): understand the Advanced Mathematics and its applications
PSO2): compete in various national and international competitive examinations.
PSO3): Students are able to formulate and develop mathematical arguments in a logical manner.
PSO4): Students will become employable in various govt. and private sectors

4.3 Programme Specific Outcome OF UG III Year / Bachelor of Science

After completing this course, the student will have:

PSO1): Basic knowledge in the field of Modern Pure and Applied Mathematics, which is most important at both post graduate and Research level.

PSO2): sufficient subject matter competence and enable students to prepare for various competitive examinations such as IIT-JAM, GATE, GRE, UGC-CSIR, NET/JRF and Civil Services Examinations etc.
PSO3): Students are motivated and prepare for research studies in mathematics and related fields.
PSO4): Student is equipped with mathematical modeling ability, critical mathematical thinking, and problem-solving skills etc.

4.4 Programme Specific Outcome OF UG IV Year / Bachelor of Science (with Research) in Mathematics
After completing this course, the student will have:

PSO1): Have a strong foundation in core areas of Mathematics, both pure and applied.
PSO2): Student should be able to think in a critical manner and develop problem solving skills.
PSO3): Communicate mathematical ideas effectively, in writing as well as orally.
PSO4): Able to formulate and develop mathematical arguments in a logical manner.

5. Eligibility for admission:

Any candidate who has passed the Plus Two of the Higher Secondary Board of Examinations in any state recognized as equivalent to the Plus Two of the Higher Secondary Board in with not less than 45 % marks in aggregate is eligible for admission, However, SC/ST, OBC and other eligible communities shall be given relaxation as per University rules.

COURSE NAME: DIFFERENTIAL CALCULUS

Course code	:	**MATDC101**			
Course Name	:	**Differential Calculus**			
Semester /Year	:	**SEMESTER - I**			
		L	T	P	C
		4	0	0	4

Course Objectives:
Student will be able to understand differentiation and fundamental theorem in differentiation and various rules. Verify the value of the limit of a function at a point using the definition of the limit. Learn to check function is continuous understand the consequences of the intermediate value theorem for continuous functions.

Course outcomes (COs):
Upon successful completion of the course a student will be able to

CO1	Identify the notions of limit of a sequence and convergence of a series of real numbers.
CO2	Interpret tracing of curves, different theorem based questions.
CO3	Examine successive differentiation by Leibnitz theorem, Indeterminate forms.
CO4	Evaluate Limit and Continuity, Tangents and normal, Indeterminate forms.
CO5	Distinguish Curvature, Asymptotes, Singular points, Tracing of curves.
CO6	Solve limit, normal, singular points, maxima minima.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Limit and Continuity (ε and δ definition), Types of discontinuities, Differentiability of functions. Cauchy's definition, Uniform continuity, boundedness theorem, Intermediate value theorem, extreme value theorem, Darboux's intermediate value theorem for derivatives and Chain rule.	15
II	Successive differentiation, Leibnitz's theorem, Partial differentiation, Euler's theorem on homogeneous functions, Tangents and normals.	15
III	Curvature, Asymptotes, Singular points, Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates.	15
IV	Rolle' s theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of sin x, cos x, ex, log(l+x), (1+x)m, Maxima and Minima, Indeterminate forms.	15

SUGGESTED READINGS:

1. Ganesh Prasad, *A textbook for differential calculus*, London Green & co.
2. Shanti Narayan , Differential Calculus, S.Chand& co.
3. RaiSinghania, M. D. Advanced Differential Equations. S. Chand &Company Ltd., New Delhi, 2001.
4. Simmons, G. F.Differential Equations with Appl. and Historical Notes. 2nd ed., Tata McGraw Hill, New Delhi, 2016.

COURSE NAME: ABSTRACT ALGEBRA

Course code	:	**MATDC 201**			
Course Name	:	**Abstract Algebra**			
Semester /Year	:	**SEMESTER - II**			
		L	**T**	**P**	**C**
		4	0	0	4

Course Objectives:
Student will be able to solve the problems of abelian and non abelian groups. The definition of Cosets, Index of subgroup, Lagrange's theorem, order of an element, Normal subgroups etc.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Definition of groups, subgroups, cyclic subgroups and rings.
CO2	Understand the theorems and problems regarding groups and rings etc.
CO3	Apply the properties of groups and rings to solve the problems.
CO4	Distinguish various problems regarding fields, integral domain, ideals.
CO5	Evaluate Cyclic groups from number systems, complex roots of unity, circle group, Subrings and ideals, Integral domains and fields, examples of fields: Zp, Q, R, and C etc.
CO6	Solve the commutator subgroup of group, examples of center of a group etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Definition and examples of groups, examples of abelian and non-abelian groups, the group Zn of integers under addition modulo n and the group U(n) of units under multiplication modulo n. Cyclic groups from number systems, complex roots of unity, circle group.	15
II	The general linear group GLn (R), the special linear group SLn (R), the permutation group Sym (n), Group of quaternions, Subgroups, cyclic subgroups.	15
III	The concept of a subgroup generated by a subset and the commutator subgroup of group, examples of subgroups including the center of a group.Cosets, Index of subgroup.	15
IV	Lagrange's theorem, order of an element, Normal subgroups: their definition, examples, and characterizations, Quotient groups.	15

SUGGESTED READINGS:

1. V. K. Khanna and S. K. Bhambri, A course in Abstract Algebra, Vikas Publishing House Pvt (Ltd), 2014.
2. Joseph A Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1999.
3. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
4. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

COURSE NAME: ODE & PDE -I

Course code	:	**MATDC 301**			
Course Name	:	**ODE & PDE -I**			
Semester /Year	:	**SEMESTER - III**			
		L	T	P	C
		4	0	0	4

Course Objectives:
Student will be able to solve first order differential equations utilizing the standard techniques for separable, exact, linear, homogeneous. Student will be able to find the complete solution of a non-homogeneous differential equation as a linear combination of the complementary function and a particular solution. Student will have a working knowledge of basic application problems described by second order linear differential equations with constant coefficients.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
CO2	Understand the genesis of ordinary differential equations.
CO3	Apply the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.
CO4	Classify mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.
CO5	Evaluate differential equation of first order, Linear homogenous equations.
CO6	Solve Charpit's method based questions, Simultaneous differential equations.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	First order exact differential equations. Integrating factors, rules to find an integrating factor.	15
II	First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian and its properties. Solving a differential equation by reducing its order.	15
III	Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.	15
IV	Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.	15

SUGGESTED READINGS:

1. M.D. Raisinghania: Ordinary and Partial Differential Equations S. Chand & Company Ltd., New Delhi, 2001.
2. M. D. Raisinghania, Advanced Differential Equations. S. Chand & Company Ltd., New Delhi, 2001.

3. Schaum's, Outlines of Differential Equations, McGraw-Hill, International Education Pvt Ltd.
4. B. Rai, D.P. Choudhary & H. J. Freedman, A Course in Differential Equations, Narosa, 2002
5. Shepley L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, 1984.
6. I. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, International Edition, 1967.
7. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata –McGraw Hill 2002
Suggested digital platform: NPTEL/SWAYAM/MOOCs

COURSE NAME: REAL ANALYSIS

Course code	:	**MATDC 401**				
Course Name	:	**Real Analysis**				
Semester /Year	:	**SEMESTER - IV**				
			L	T	P	C
			4	0	0	4

Course Objectives:
Describe fundamental properties of the real numbers that lead to the formal development of real analysis. Comprehend rigorous arguments developing the theory underpinning real analysis. Demonstrate an understanding of limits and how they are used in sequences, series, Construct rigorous mathematical proofs of basic results in real analysis

Course outcomes (COs):
Upon successful completion of the course a student will be able to

CO1	Select the limit superior, limit inferior, and the limit of a bounded sequence.
CO2	Understand many properties of the real line $\mathbb{R}$ and learn to define sequence in terms of functions from $\mathbb{R}$ to a subset of $\mathbb{R}$.
CO3	Apply the ratio, root and alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
CO4	Classify some of the properties of Riemann integral functions and the applications of the fundamental theorems of integration.
CO5	Test the convergence of the infinite series by Ratio test, P test, Root test etc
CO6	Solve the questions based on M, Mn test and Leibnitz test etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.	15
II	Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).	15
III	Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series.	15
IV	Leibnitz's test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence. Sequences and series of functions, Point-wise and uniform convergence. Mn-test, M-test.	15

SUGGESTED READINGS:

1. S.C. Malik & Savita Arora, Mathematical Analysis, New age international publisher.
2. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd., 2000.
3. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.
4. T. M. Apostol, Calculus (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.

COURSE NAME: LINEAR ALGEBRA

Course code	:	**MATDC 501**				
Course Name	:	**LINEAR ALGEBRA**				
Semester /Year	:	**SEMESTER - V**				
			L	T	P	C
			4	0	0	4

Course Objectives:
Introduction to vector space and subspace. Use computational techniques and algebraic skills essential for the study of systems of Linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors, Orthogonality and Diagonalization. (Computational and Algebraic Skills).

Course outcomes (COs):
Upon successful completion of the course a student will be able to

CO1	Define linear transformations; compute eigen values and eigen vectors.
CO2	Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
CO3	Apply properties of inner product spaces and determine orthogonality in inner product spaces.
CO4	Compare the properties of Isomorphism, Homomorphism etcand use in change of coordinate matrix.
CO5	Evaluate Eigen values and Eigen vectors, Characteristic Polynomial , linear combination of vectors, linear independence etc.
CO6	Solve linear transformations, Characteristic Polynomial, linear combination of vectors etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.	15
II	Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation.	15
III	Algebra of linear transformations. Dual Space, Dual Basis, Double Dual, Eigen values and Eigen vectors, Characteristic Polynomial.	15
IV	Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.	15

SUGGESTED READINGS:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
2. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education 20 Asia, IndianReprint, 2007.
3. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
4. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
Suggested digital platform: NPTEL/SWAYAM/MOOCs

COURSE NAME: COMPLEX ANALYSIS-I

Course code	:	**MATDC 601**			
Course Name	:	**COMPLEX ANALYSIS-I**			
Semester /Year	:	**SEMESTER - VI**			
		L	T	P	C
		4	0	0	4

Course Objectives:

Compute sums, products, quotients, conjugate, modulus, and argument of complex numbers. Define and analyze limits and continuity for complex functions as well as consequences of continuity. Conceive the concepts of analytic functions and will be familiar with the elementary complex functions and their properties.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Gain knowledge of sketching different surfaces like parabola, ellipse etc. Identify the isolated singularities of a function and determine whether they are removable, poles, or essential.
CO2	Understand the significance of differentiability for complex functions and be familiar with the Cauchy-Riemann equations.
CO3	Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and Illustrate the related problems .
CO4	Distinguish the properties of various terms. Analyze functions as Taylor, power and Laurent series, find residues and Evaluating complex integrals using the residue theorem.
CO5	Discriminate Analytic functions, exponential function, limits, Liouville's theorem and mappings etc, Evaluate the problems.
CO6	Write the techniques for Limits, continuity, derivatives of functions ,upper bounds ,Taylor and Laurent series and construct the related solutions.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas.	15
II	Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions.	15
III	Definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula.	15
IV	Liouville's theorem and Taylor and Laurent series and its examples.	15

SUGGESTED READINGS:

1. S Ponnusamy, Functions of Complex Analysis, Narosa, 2005.
2. Shanti Narain , Function of Complex Variable, S Chand, 2005.
3. J.W. Brown and R.V. Churchill, Complex Variables and Applications, McGraw Hill International Edition, 2009.
4. J.B. Conway, Function of One Complex Variable, Narosa, Delhi.

Suggested digital platform: NPTEL/SWAYAM/MOOCS

COURSE NAME: ODE & PDE -II

Course code	:	**MATDC 701**			
Course Name	:	**ODE & PDE -II**			
Semester /Year	:	**SEMESTER - VII**			
		L	T	P	C
		4	0	0	4

Course Objectives:
The aims of this course is to familiarize the learner with elementary terms like as Wronskian, Ordinary points, Regular and singular points of ODE and Classification of PDE after that Picard iteration methods, Uniqueness and existence theorem of ODE, and some standard ODE: Legendre's and Bessel's differential equations, solution of some standard linear and nonlinear PDE.

Course Outcomes (Cos): After completion of this course the student will be able to the following

CO1.	Remembering elementary terms like as Wronskian, Ordinary points, Regular and singular points of ODE and all other terms related to ODE and PDE etc.
CO2.	Understand the ODE, PDE problems and Frobenius series solution for Legendre's and Bessel's differential equations with generating functions and Uniqueness and existence theorem etc.
CO3.	Classification of PDE of 2nd order and canonical forms, Concept of Method of separation of variables and other problems s related to ODEs and PDEs.
CO4.	Analysis the theory of ordinary differential equations through applications, methods of solution and numerical approximations like as Picard iteration methods.
CO5.	Determine what function or functions satisfy the differential equations.
CO6.	Develop new solutions related to PDE and ODE.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Ordinary differential equations: Qualitative properties of solution, Oscillation, Wronskian, Sturm separation and comparison theorem, Picard iteration methods, Uniqueness and existence theorem.	12
II	Ordinary points, Regular and singular points, Frobenius series solution for Legendre's and Bessel's differential equations with generating functions.	12
III	Classification of PDE of 2nd order and canonical forms, Concept of separation of variable solution.	12
IV	Solution of heat diffusion, Laplace and wave equations, Non-linear partial differential equation of second order.	12

SUGGESTED READINGS:

1. Simmons, G. F.; Differential Equations with Applications and Historical Notes. 2nd edition, Tata McGraw Hill, New Delhi, 2016.
2. Evans, L. C.; Partial Differential Equations, 2nd edition, The Orient Blackswan, 2014.
3. Ross, S. L.; Differential Equations. 3rd edition, Wiley India, 2007.
4. Sneddon, I. N.; Elements of Partial Differential Equations. Dover Publications, 2006.
5. Raisinghania, M. D.; Advanced Differential Equations. S. Chand & Company Ltd., New Delhi, 2001.
6. Reid, W. T.; Ordinary Differential Equations. John Wiley and Sons, New York, 1971.
7. Rai, B., Chaudhary, D.P. & Freedman, H.I.; A Course in ODE: Alpha Sci. Int. Ltd.

COURSE NAME: COMPLEX ANALYSIS-II

Course code	:	**MATDC 801**				
Course Name	:	**Complex Analysis-II**				
Semester /Year	:	**SEMESTER - VIII**				
			L	T	P	C
			4	0	0	4

Course Objectives:

The aims of this course is to familiarize the learner with the applications of complex variable and conformal mapping in two dimensional complex potential theories. The fundamental calculus theorems and criteria for the independent path on contour integral used in problems of engineering. The concepts of special functions and its application for solving the partial differential equations in physics and engineering. The mathematics of combinatorial enumeration by using generating functions and complex analysis for understanding the numerical growth rates.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Identify the fundamental concepts of analyticity and differentiability for calculus of complex functions and their role in applied context.
CO2	Utilize the concepts of analyticity for finding complex conjugates and their role in applied contexts. Make use of the conformal mapping technique for transferring geometric structure of complex functions with much more convenient geometry.
CO3	Apply integral theorems of complex analysis and its consequences for the analytic function with derivatives of all orders in simple connected region.
CO4	Extend the Taylor and Laurent series for expressing the function in terms of complex power series.
CO5	Classify Singularities and Poles of Complex functions for evaluating definite and indefinite Complex integrals.
CO6	Apply Residue theorem for computing definite integrals of real and complex analytic functions over closed curves.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Line integral: Evaluation along a path and by indefinite integration; Cauchy's integral theorem; Cauchy's integral formula; Generalized integral formula; Power series expansions of complex functions and contour Integration: Radius of convergence.	15
II	Expansion in Taylor's series, Maclaurin's series and Laurent series. Singular point; Isolated singular point; Pole of order m; Essential singularity;	15
III	Residue: Cauchy Residue Theorem. Evaluation of Residue by Laurent Series and Residue Theorem.	15
IV	Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Zn the ring of integers modulo n, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integral domains and fields, examples of fields: Zp, Q, R, and C.	15

SUGGESTED READINGS:

1. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons Publishers, 10th Edition,2010
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 43rd Edition, 2015.
3. T.K.V Iyengar, B.Krishna Gandhi, "Engineering Mathematics - III", S.Chand & Co., 12th Edition, 2015.
4. RK Jain & SRK Iyengar, "Advanced Engineering Mathematics", Narosa Publishers, 5th Edition, 2016.

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DISCIPLINE SPECIFIC ELECTIVE COURSE

(THEORY OF EQUATIONS)

Course code	:	**MATDE501**
Course Name	:	**Theory of Equations**
Semester /Year	:	**V /3rd**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: Student will able to solve the problems of polynomials, maximum and minimum values of a polynomials. Descarte 's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations. Symmetric functions. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic.

Course Outcome (COs): After completion of this course the student will be able to the following

CO1.	Describe & Identify the basic properties & definitions of Theory of equations and related examples related to polynomials, equations and Symmetric functions etc.
CO2.	Explain conceptual based problems of Theory of equations and their solutions.
CO3.	Solve the problems of roots and the coefficients of equations etc.
CO4.	Analyze the problems related to polynomials, roots and the coefficients of equations, reciprocal and binomial equations and Algebraic solutions of the cubic and biquadratic etc.
CO5.	Evaluate the problems related to polynomials, roots and the coefficients of equations, reciprocal and binomial equations and Algebraic solutions of the cubic and biquadratic etc.
CO6.	Design and formulate the problems based on polynomials, roots and the coefficients of equations, reciprocal and binomial equations and Algebraic solutions of the cubic and biquadratic etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	General properties of polynomials, Graphical representation of a polynomials, maximum and minimum values of a polynomials	12
II	General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.	12
III	Symmetric functions, Applications of symmetric function of the roots, Transformation of equations.	12
IV	Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.	12

SUGGESTED READINGS:

1. W.S. Burnside and A.W. Panton, *The Theory of Equations,* Dublin University Press, 1954.
2. C. C. MacDuffee, *Theory of Equations,* John Wiley & Sons Inc., 1954.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS

DISCIPLINE SPECIFIC ELECTIVE COURSE
(Matrices)

Course code	:	**MATDE601**
Course Name	:	**Matrices**
Semester /Year	:	**VI /3rd**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: This course familiarizes the students with the theory of matrices which are used in solving equations in mechanics and other streams used in Mathematics, Physics etc.

Course Outcome (COs): After completion of this course the student will be able to the following

CO1.	Describe & Identify the basic properties & definitions related to Matrices and related examples etc.
CO2.	Explain conceptual based problems of Matrices and homogeneous and non-homogeneous linear equations and their solutions.
CO3.	Solve the problems of Matrices and homogeneous and non-homogeneous linear equations etc.
CO4.	Analyze the problems related to LI & LD vectors, Rank of a matrix, Characteristic roots and characteristic vectors. Nature of Characteristics roots of special matrices. Cayley-Hamilton Theorem etc.
CO5.	Evaluate the problems related to LI & LD vectors, Rank of a matrix, Characteristic roots and characteristic vectors. Nature of Characteristics roots of special matrices. Cayley-Hamilton Theorem etc.
CO6.	Design and formulate the problems based on to LI & LD vectors, Rank of a matrix, Characteristic roots and characteristic vectors. Nature of Characteristics roots of special matrices. Cayley-Hamilton Theorem etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Basic of Matrices, Symmetric and Skew symmetric, Hermitian and Skew Hermitian, Orthogonal and Unitary matrices (Definitions and examples only).Rank of a matrix, elementary transformations, reduction to normal form (methods only), elementary matrices, equivalence of matrices.	12
II	Vector as n-tuples. Linear dependence and independence of vectors. Rank of a matrix. Row rank, Column Rank and Determinant Rank of a matrix. System of linear equations, consistency and inconsistency. Homogeneous and non-homogeneous equations. Gauss method of solving a system of equations.	12
III	Characteristic equation of a square matrix. Characteristic roots and characteristic vectors. Nature of Characteristics roots of special matrices. Cayley-Hamilton Theorem (statement only). Orthogonal reduction of real symmetric matrices. (method only)	12
IV	Unitary reduction of Hermitian Matrices (method only). Similarity of matrices. Reduction to Diagonal form, diagonalizable matrices.	12

SUGGESTED READINGS:

1. Shanti Narayan & P. K. Mittal, A Text Book of Matrices, S. Chand & Co. Ltd., New Delhi, Reprint 2002.
2. R.K. Jain & S.R.K. Iyengar: Advanced Engineering Mathematics (Narosa Publishing House), 2nd edition, 2005.

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DISCIPLINE SPECIFIC ELECTIVE COURSE
(Analytical Geometry)

Course code	:	**MATDE701**
Course Name	:	**Analytical Geometry**
Semester /Year	:	**VII/4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: To add, subtract, multiply, divide, and identify the composition of functions. Identify and graph the inverse of a function Evaluate logarithms, including common and natural logarithms. Solve exponential and logarithmic equations and convert between the two notations, Use various properties of logarithms to solve equations, Graph parabolas and circles based on properties from their standard form equations, Locate angles in standard position, Measure angles in radians and degrees, and convert between the two units understand the unit circle and identify trigonometric function values of an angle given a point on the unit circle (or on any size circle), Define and use trigonometric ratios to evaluate trigonometric function values for an acute angle in a right triangle, Understand and graph trigonometric functions.

Course Outcome (COs): After completion of this course the student will be able to the following

CO1.	Describe & Identify the basic properties & definitions related to analytical geometry of 2D and related examples etc.
CO2.	Explain conceptual based problems based on parabola, ellipse and hyperbola and their solutions.
CO3.	Solve the problems of parabola, ellipse and hyperbola etc.
CO4.	Analyze the problems related to parabola, ellipse and hyperbola and quadratic equations representing lines, parabola, ellipse and hyperbola etc.
CO5.	Evaluate the problems related to parabola, ellipse and hyperbola and quadratic equations representing lines, parabola, ellipse and hyperbola etc.
CO6.	Design and formulate the problems based on parabola, ellipse and hyperbola and quadratic equations representing lines, parabola, ellipse and hyperbola etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Introduction to parabola, ellipse and hyperbola. Techniques for sketching parabola, ellipse and hyperbola.	12
II	Reflection properties of parabola, ellipse and hyperbola, Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.	12
III	Sphere, Cone, Cylindrical Surfaces, Spheres, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid. Central Conicoids.	12
IV	General equation of second degree, Central conicoids, Tangent plane, Director sphere, Normal, Plane of contact, Polar plane, Conjugate plane and conjugate points.	12

SUGGESTED READINGS:

1. S.L. Loney, *The Elements of Coordinate Geometry,* McMillan and Company, London.
2. *R.J.T. Bill,* Elementary Treatise on Coordinate Geometry of Three Dimensions, *McMillan India Ltd., 1994*
3. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
4. Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

DISCIPLINE SPECIFIC ELECTIVE COURSE
(Transport and Game Theory)

Course code	:	**MATDE702**
Course Name	:	**Transport and Game Theory**
Semester /Year	:	**VII /3rd**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: Student will be able to solve the transportation problem. Algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method. Game theory: formulation of two person zero sum games, solving two person zero sum games etc.

Course Outcome (COs): After completion of this course the student will be able to the following

CO1.	Define the transportation problems and its mathematical formulation.
CO2.	Understand the formulation of two person zero sum games.
CO3.	Use Hungarian method for solving assignment problem.
CO4.	Compare the northwest – corner method, least cost method, vogel approximation method etc.
CO5.	Evaluate Transportation problem and its mathematical formulation etc.
CO6.	Solve Games with mixed strategies, two person zero sum games etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution.	12
II	Algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.	12
III	Game theory: formulation of two person zero sum games, solving two person zero sum games.	12
IV	Games with mixed strategies, graphical solution procedure.	12

SUGGESTED READINGS:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and NetworkFlows, 2nd Ed., John Wiley and Sons. India, 2004.
2. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

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DISCIPLINE SPECIFIC ELECTIVE COURSE
(Fundamentals of Differential Geometry)

Course code	:	**MATDE703**
Course Name	:	**Fundamentals of Differential Geometry**
Semester /Year	:	**VII /4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: In this course, students will be able to understand several concepts of Differential Geometry such as curves in plane & space. surfaces, curvatures, torsion, and geodesics.

Course Outcome (COs): After completion of this course the student will be able to the following

CO1.	Describe & Identify the basic properties & definitions related to Curves in the planes and in space, arc length, Curvature, torsion, Osculating circles, Gaussian Curvature, Gauss map, Geodesics and related examples etc.
CO2.	Explain conceptual problems based on Curves in the planes and in space, arc length, Curvature, torsion, Osculating circles, Gaussian Curvature, Gauss map, Geodesics and their solutions.
CO3.	Solve the problems of Curves in the planes and in space, arc length, Curvature, torsion, Osculating circles, Gaussian Curvature, Gauss map, Geodesics etc.
CO4.	Analyze the problems related to Curves in the planes and in space, arc length, Curvature, torsion, Osculating circles, Gaussian Curvature, Gauss map, Geodesics etc.
CO5.	Evaluate the problems related to Curves in the planes and in space, arc length, Curvature, torsion, Osculating circles, Gaussian Curvature, Gauss map, Geodesics etc.
CO6.	Design and formulate the problems based on Curves in the planes and in space, arc length, Curvature, torsion, Osculating circles, Gaussian Curvature, Gauss map, Geodesics etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Theory of Space Curves: Curves in the planes and in space, arc length, Curvature, torsion, Osculating circles	12
II	Theory of Surfaces: smooth surfaces, tangents, normal and orientability, quadric surfaces, the first and the second fundamental forms (only statements and related examples),	12
III	Gaussian Curvature & Gauss map: Principal and Gaussian curvatures, mean curvatures, the pseudo sphere, flat surfaces, surfaces of constant mean curvature, Gaussian curvature of compact surfaces, the Gauss map.	12
IV	Geodesics: Geodesics, geodesic equations (without proof), geodesics as shortest paths, geodesic coordinates, Nature of geodesics on a surface of revolution.	12

SUGGESTED READINGS:

1. Alferd Gray, Modern Differential Geometry of Curves and Surfaces with Mathematica, 2018. (4th edition). Chapman & Hall/CRC Press, Taylor & Francis, (Textbook).
2. A. Pressley,Elementary Differential Geometry. 2nd edition, Springer, (Textbook).
3. Christian Bär, Elementary Differential Geometry. Cambridge University Press, 2010.
4. T.J. Willmore, *An Introduction to Differential Geometry,* Dover Publications, 2012.
5. B. O'Neill, *Elementary Differential Geometry,* 2nd Ed., Academic Press, 2006.

DISCIPLINE SPECIFIC ELECTIVE COURSE
(Statics)

Course code	:	**MATDE 704**
Course Name	:	**Statics**
Semester /Year	:	**VII / 4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: This course is an introduction to statics, that is, the bodies at rest under action of forces. Students will be introduced to the concept of force, their addition and resolution, moments, couples, friction and equilibrium conditions. In addition, the centre of mass, gravity and stability of body will be taught.

Course Outcome (COs): After completion of this course the student will be able to the following

CO1.	Describe & Identify the basic properties & definitions related to Forces acting on a particle, Parallel forces, Friction, Virtual Work and related examples etc.
CO2.	Explain conceptual problems based on Forces acting on a particle, Parallel forces, Friction, Virtual Work and their solutions.
CO3.	Solve the problems of Forces acting on a particle, Parallel forces, Friction, Virtual Work etc.
CO4.	Analyze the problems related to Forces acting on a particle, Parallel forces, Friction, Virtual Work etc.
CO5.	Evaluate the problems related to Forces acting on a particle, Parallel forces, Friction, Virtual Work etc.
CO6.	Design and formulate the problems based on Forces acting on a particle, Parallel forces, Friction, Virtual Work etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	**Basic notions:** Inertial and non-inertial frame of reference, Weight of body, Force, Force with contact and without contact, Force systems, Principle of transmissibility of forces, Basic concepts of mechanics.	12
II	**Forces acting on a particle:** Parallelogram law of forces, Triangle law of forces and its converse, Polygon of forces, λ-μ Theorem (without proof), Lami's theorem and its converse (without proof), Components of a force in given directions.	12
III	**Parallel forces:** Resultant of two like parallel forces, unequal unlike parallel forces, Theorem of resolved parts of two parallel forces, Centre of parallel forces, Centre of gravity.	12
IV	**Friction:** Definition and nature of friction, coefficient of friction, angle of friction, cone of friction, laws of friction, equilibrium of a particle on a rough plane, Problems on ladders, rods etc. **Virtual Work**: Work done by a force, Principle of virtual work with Applications	12

SUGGESTED READINGS:

1. The Elements of Statics and Dynamics: Part 1 (Statics) by S. L. Loney, Published by Arihant Prakashan, Meerut.
2. Statics by A. S. Ramsey, Second Edition, CBS Publishers.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

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DISCIPLINE SPECIFIC ELECTIVE COURSE
(Number Theory)

Course code	:	**MATDE 705**
Course Name	:	**Number Theory**
Semester /Year	:	**VII/ 4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Course Objective: It is intended to introduce students to number theoretic problems and to different areas of number theory. It has many applications, especially to coding theory and cryptography.

Course Outcome (COs): After completion of this course the student will be able to:

CO1.	Describe & Identify the basic properties & definitions related to the on Arithmetic functions, Divisibility, congruences, Linear Diophantine equation, Prime numbers and related examples.
CO2.	Explain conceptual problems based on the on Arithmetic functions, Divisibility, congruences, Linear Diophantine equation, and Prime numbers.
CO3.	Solve the various type of problems of the on Arithmetic functions, Divisibility, congruences, Linear Diophantine equation, Prime numbers.
CO4.	Develops ability to analyse the problems on Arithmetic functions, Divisibility, congruences, Linear Diophantine equation, and Prime numbers.
CO5.	Evaluate the problems related to on Arithmetic functions, Divisibility, congruences, Linear Diophantine equation, and Prime numbers.
CO6.	Develops ability to formulate real world problems based on Arithmetic functions, Divisibility, congruences, Linear Diophantine equation, Prime numbers.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Divisibility, Greatest common divisor, Euclidean algorithm, The Fundamental theorem of arithmetic, Congruences, Residue classes and reduced residue classes, Chinese remainder theorem, Fermat's little theorem.	12
II	Number theoretic functions for sum and number of divisors, Multiplicative function, The Möbius inversion formula, Greatest integer function, Euler's phi-function and properties, Arithmetic functions $d(n)$, $\sigma(n)$, $\mu(n)$, Euler's theorem, Wilson's theorem	12
III	Primitive roots and indices. Quadratic residues, Legendre symbol, Euler's criterion, Gauss's lemma, Quadratic reciprocity law, Jacobi symbol.	12
IV	Linear Diophantine equation, Prime counting function, Prime number theorem , Goldbach conjecture, Twin-prime conjecture, Odd perfect numbers conjecture, Fermat and Mersenne Primes	12

SUGGESTED READINGS:

1. G. H. Hardy and E. M. Wright – An Introduction to Theory of Numbers, *Oxford* University Press, 6th Ed , 2008.
2. I. Niven, H. S. Zuckerman and H. L. Montgomery – An Introduction to the Theory of Numbers, John Wiley and Sons, (Asia) 5th Ed.
3. H. Davenport - The Higher Arithmetic, Camb. Univ. Press, 7th edition, (1999)
4. David M. Burton – Elementary Number Theory, Tata McGraw Hill, 6th Edition, 2007.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

DISCIPLINE SPECIFIC ELECTIVE COURSE
(Discrete Mathematics)

Course code	:	**MATDE 801**
Course Name	:	**Discrete Mathematics**
Semester /Year	:	**VIII/4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: The primary objective of the course is that students should learn a particular set of mathematical facts and how to apply them. In particular it teaches students how to think logically and mathematically through five important themes: mathematical reasoning, combinatorial analysis, discrete structures, algorithmic thinking, and applications and modeling. A successful discrete mathematics course should carefully blend and balance all five themes.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe & Identify the basic properties & definitions related to logic & proofs, combinatorics, recurrence relations, lattices and related examples etc.
CO2.	Explain conceptual problems based on logic & proofs, combinatorics, recurrence relations, lattices.
CO3.	Solve the various type of problems of logic & proofs, combinatorics, recurrence relations and lattices .
CO4.	Develops ability to analyze the problems on logic & proofs, combinatorics, recurrence relations, lattices.
CO5.	Evaluate the problems related to logic & proofs, combinatorics, recurrence relations, lattices etc.
CO6.	Develops ability to formulate real world problems based on logic & proofs, combinatorics, recurrence relations, lattices

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	**LOGIC AND PROOFS**: Propositional logic, Propositional equivalences, Predicates and quantifiers, Nested quantifiers, Rules of inference, Introduction to proofs, Proof methods and strategy.	12
II	**COMBINATORICS:** Mathematical induction, Strong induction and well ordering, The pigeonhole principle, Basic counting principles, Permutations and combinations, Inclusion and exclusion principle and its applications.	12
III	**Recurrence relations:** recurrence relations, Generating functions, solution of recurrence relations using difference equations and generating functions, Catalan numbers, Difference sequences and Sterling numbers.	12
IV	**LATTICES:** Partial ordering, Posets, Lattices as posets, Properties of lattices, Lattices as algebraic systems, Sub lattices, Direct product and homomorphism, Some special lattices,	12

SUGGESTED READINGS:

1. *C. L. Liu: Elements of discrete mathematics, Tata McGraw Hill Education, 2008.*
2. *Ram Babu: Disrete Mathematics, Pearson Edition India, 2011.*
3. *Lipschutz: Disrete Mathematics, Tata McGraw Hill, 2011.*
4. R.A. Brualdi: Introductory Combinatorics, 5th Edition, Pearson, 2010.
5. J. L. Mott, Kandel and T. P. Baker: Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall, 1986.

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DISCIPLINE SPECIFIC ELECTIVE COURSE
(Mathematical Statistics)

Course code	:	**MATDE 802**
Course Name	:	**Mathematical Statistics**
Semester /Year	:	**VIII/4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: The student will use this knowledge in computer science, finance mathematics, industrial mathematics and bio mathematics. After completion of this course students appreciate its interdisciplinary nature.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe & Identify the basic properties & definitions related to random variables, probability mass/density functions, mathematical expectation, moment generating function, characteristic function, discrete distributions, joint probability density functions, Marginal and conditional distributions and related examples.
CO2.	Explain conceptual problems based on basic probability and probability distributions mathematical expectation etc.
CO3.	Solve the various types of problems of basic probability and probability distributions.
CO4.	Develops ability to analyze the problems on basic probability and probability distributions.
CO5.	Evaluate the problems related to basic probability and probability distributions
CO6.	Develops ability to formulate real world problems based basic probability and probability distributions.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation.	12
II	Moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal, exponential	12
III	Joint cumulative distribution function and its properties, joint probability density functions	12
IV	Marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables.	12

SUGGESTED READINGS:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics,* Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Applications,* 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, *Introduction to Probability Models,* 9th Ed., Academic Press, Indian Reprint, 2007.
4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, *Introduction to the Theory of Statistics,* 3rd Ed., Tata McGraw- Hill, Reprint 2007

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

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DISCIPLINE SPECIFIC ELECTIVE COURSE
(Dynamics)

Course code	:	**MATDE 803**
Course Name	:	**Dynamics**
Semester /Year	:	**VIII/4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: This course is to study the motion of moving body. Students will be introduced to the concept of motion along a straight line with constant and variable acceleration. In addition, motion in a plane, SHM, projectile, work, power energy and momentum will be taught.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe uniform motion, position, displacement, velocity, acceleration, uniform velocity, Linear momentum etc.
CO2.	Explain Newton's Laws of Motion, Motion of two particles connected by a string etc.
CO3.	Solve Simple harmonic motion related problems.
CO4.	Develop the problems related to motion along a smooth inclined plane, constrained motion along a smooth inclined plane.
CO5.	Evaluate Linear momentum, angular momentum, conservation of angular momentum.
CO6.	Distinguish relative displacement, velocity and acceleration etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	**Basic notions:** Kinematics, kinetics, uniform motion, position, displacement, velocity, acceleration, uniform velocity, Linear momentum. **Motion of a particle in a straight line:** Motion of a particle with constant acceleration, motion of a body let fall free from rest, motion of a body projected vertically upwards	12
II	**Newton's Laws of Motion:** Newton's Laws of Motion, Motion of two particles connected by a string, Motion along a smooth inclined plane, constrained motion along a smooth inclined plane. **Variable acceleration:** Simple harmonic motion.	12
III	**Motion of a particle in a plane:** Composition and resolution of velocities and Acceleration in a plane, Projectiles, motion in a circle, Motion under constraint.	12
IV	**Relative motion:** Relative displacement, velocity and acceleration, motion relative to a rotating frame of reference. **Momentum**: Linear momentum, angular momentum, conservation of angular momentum.	12

SUGGESTED READINGS:

1. Dynamics by A. S. Ramsey, Cambridge University Press.
2. The Elements of Statics and Dynamics: Part 2 (Dynamics) by S. L. Loney, Arihant Prakashan, Meerut.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

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DISCIPLINE SPECIFIC ELECTIVE COURSE
(Numerical Analysis)

Course code	:	**MATDE 804**
Course Name	:	**Numerical Analysis**
Semester /Year	:	**VIII/ 4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: To acquaint the students with Numerical approximations, convergence problems, Solution of Transcendental and polynomial equations, Different rules of Finite difference operators and Interpolation.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe & Identify the basic properties & definitions related to Numerical approximations, convergence problems and Solution of Transcendental and polynomial equations, Different rules of Finite difference operators and Interpolation and related examples.
CO2.	Explain conceptual problems based on Numerical approximations, convergence problems, Solution of Transcendental and polynomial equations, Different rules of Finite difference operators and Interpolation etc.
CO3.	Solve the various type of problems of Numerical approximations, convergence problems, Solution of Transcendental and polynomial equations, Different rules of Finite difference operators and Interpolation.
CO4.	Develops ability to analyse the problems on Numerical approximations, convergence problems, Solution of Transcendental and polynomial equations, Different rules of Finite difference operators and Interpolation.
CO5.	Evaluate the problems related to Numerical approximations, convergence problems, Solution of Transcendental and polynomial equations, Different rules of Finite difference operators and Interpolation
CO6.	Develops ability to formulate real world problems on Numerical approximations, convergence problems, Solution of Transcendental and polynomial equations, Different rules of Finite difference operators and Interpolation.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Approximate numbers and significant digits, rounding off a number, type of errors viz inherent, truncation, absolute, relative and percentage errors, general error formula, error in addition, subtraction, multiplication, division and exponent of numbers, error in a series approximation.	12
II	Solution of Transcendental and Polynomial equations: Bisection method, Newton-Raphson method, Secant method. Method of False Position, Fixed point iterative method, and Graeffe's root squaring methods. Order and rate of convergence of these methods.	12
III	Finite difference operators viz forward, backward, central, average, shift and divided difference operators, relation between finite difference operators, finite differences of a polynomial and transcendental functions, missing term technique, detection of errors by finite difference table.	12
IV	Interpolation: Newton's forward and backward interpolation formulae, Gauss's forward and backward difference interpolation formulae, Lagrange's interpolation and Newton's divided difference interpolation formulae for unevenly spaced points.	12

SUGGESTED READINGS:

1. F. B. Hildebrand, Introduction to Numerical Analysis, McGraw-Hill, N.Y.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, Pvt. Ltd.

3. C. E. Froberg, Introduction to Numerical Analysis, Addison-Wesley.
4. M.K. Jain, S.R.K Iyengar and R.K.Jain, Numerical methods for Scientific and Engineering Computation, New Age International Pub.
5. R. V. Dukkipati, Applied Numerical methods, New Age International Pub.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

DISCIPLINE SPECIFIC ELECTIVE COURSE
(Multivariate Calculus)

Course code	:	**MATDE 805**
Course Name	:	**Multivariate Calculus**
Semester /Year	:	**VIII/ 4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	3	1	0	4
Hours/ week	**3**	**1**	**0**	**4**

Objectives: The objective of this course to introduce functions of several variables to a student after he has taken a course in one variable calculus. The course will introduce partial derivatives and several of its consequences and will introduce double and triple integrals along with line integrals which are fundamental to all streams where calculus can be used. After reading this course a student will be able to calculate partial derivatives, directional derivatives and extreme values and can calculate double, triple and line integrals.
He will have idea of basic vector calculus including green's theorem, divergence theorem and stokes theorem. He can take courses in calculus on manifolds, Differential geometry and can help in numerical computations involving several variables.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Identify tangent planes, Functions of several variables, limit and continuity.
CO2.	Interpret Extreme of functions, divergence and curl.
CO3.	Examine integration over nonrectangular region.
CO4.	Evaluate Line integrals, Applications of line integrals.
CO5.	Distinguish Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stokes' theorem.
CO6.	Solve double integrals and triple integrals.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Functions of several variables, limit and continuity of functions of two variables. Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes.	12
II	Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems. Definition of vector field, divergence and curl, Double integration over rectangular region, double integration over nonrectangular region. Double integrals in polar co-ordinates.	12
III	Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co- ordinates. Change of variables in double integrals and triple integrals.	12
IV	Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path. Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stokes' theorem, The Divergence theorem.	12

SUGGESTED READINGS:

1. M. J,.Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
2. S C Mallik and S Arora: Mathematical Analysis, New Age International Publications BOOK FOR REFERENCES: 1. G.B.

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Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005. 2. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE). Indian reprint, 2005.

3. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks/Cole, Thomson Learning, USA, 2001. 4. S Ghorpade, B V Limaye, Multivariable calculus, Springer international edition.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

Skill Enhancement Courses
(Bio Mathematics)

Course code	:	**MATSC 101**
Course Name	:	**Bio Mathematics**
Semester /Year	:	**I/ 1st**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective: The course will lead to learn the development, analysis and interpretation of bio mathematical models such as population growth, cell division, and predator-prey models.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe & Identify the basic properties related to Mathematical Biology and the modeling process and related examples.
CO2.	Explain conceptual problems based on Mathematical Biology.
CO3.	Solve the various types of problems of Mathematical Biology.
CO4.	Develops ability to analyze Mathematical Biological model like as Insect Outbreak Model, continuous models and the related problems.
CO5.	Evaluate the problems related to Mathematical Biology.
CO6.	Develop the ability to solve the Mathematical Biology and the modelling process etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system,	12
II	Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.	12

SUGGESTED READINGS:

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

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Skill Enhancement Courses
(Laplace transforms)

Course code	:	**MATSC 201**
Course Name	:	**Laplace transforms**
Semester /Year	:	**II/ 1st**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective: The course will lead to learn Laplace transforms and Inverse Laplace transforms.
Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe & Identify the basic of and related examples.
CO2.	Understand the basics of Laplace transforms and Inverse Laplace transforms.
CO3.	Solve the related problems to transforms.
CO4.	Develops ability to analyze Laplace transforms and Inverse Laplace transforms.
CO5.	Create Inverse Laplace transform of derivatives and integrals.
CO6.	Develop the ability to formulate the problems on Laplace transforms and Inverse Laplace transforms.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Laplace transforms of some standard functions, Existence conditions for the Laplace transform Shifting theorems, Laplace transform of derivatives and integrals, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac Delta function.	10
II	Inverse Laplace transforms and their properties, Shifting theorems, Inverse Laplace transform of derivatives and integrals, Heaviside expansion theorem, Convolution theorem. Applications of Laplace transform to solve Ordinary differential equations	14

SUGGESTED READINGS:

1. E. Kreyszig. Advance Engineering Mathematics, John Wiley& Sons.2011.
2. R.K. Jain and S.R.K. lyenger, Advanced Engineering Mathematics, Narosa Publishing House, 2009.
3. F. B. Hildebrand, Methods of Applied Mathematics, Courier Dover Publication, 1992.

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Skill Enhancement Courses
(Elementary Algebra & Trigonometry)

Course code	:	**MATSC 301**
Course Name	:	**Elementary Algebra & Trigonometry**
Semester /Year	:	**III/ 2nd**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective: Student will be able to solve the problems of equivalence relations, logical and binding variables. Sets problems, modulo relations. De Moivre's theorem and its applications.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Knowledge of fundamental theorem of algebra.
CO2.	Understand the different types of matrices.
CO3.	Apply to solve the problems regarding matrices.
CO4.	Distinguish exponential, logarithmic, circular and hyperbolic functions.
CO5.	Evaluate the questions based on matrices, numbers etc.
CO6.	Solve the matrices , Exponential, Logarithmic, Circular and hyperbolic functions etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Numbers: Natural numbers, Integers, Rational and Irrational numbers, Real numbers, Complex numbers, Mappings, Equivalence relation and partitions, Congruence modulo n. Roots of equations: Fundamental Theorem of Algebra, Relations between Roots and Coefficients, transformation of equations, Descartes rule of signs, Algebraic Solution of a Cubic equations (Carden method), Bi-quadratic Equation.	14
II	Elementary Matrices: Symmetric, skew-symmetric, Hermitian and skew-Hermitian matrices; Elementary operations on matrices, adjoint and inverse of a matrix. Trigonometry: De Movire's Theorem and its applications, Exponential, Logarithmic, Circular and hyperbolic functions together with their inverses, Gregory's series, Summation of Trigonometric series.	10

SUGGESTED READINGS:

1. Leonard E. Dickson: First Course in the Theory of Equations.
2. John Bird: Engineering Mathematics, Fifth edition.
3. Rajendra Kumar Sharma etc. Complex Numbers and the Theory of Equations, Anthom Press India.

Skill Enhancement Courses
(Numerical Methods for ODE)

Course code	:	**MATSC 401**
Course Name	:	**Numerical Methods for ODE**
Semester /Year	:	**IV/2nd**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective: To develop the ability in students of using the different methods in certain given conditions.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe & Identify the basic Numerical differentiation, Numerical Integration and related examples.
CO2.	Understand the basics of Numerical differentiation, Numerical Integration
CO3.	Explore Numerical differentiation and Numerical Integration.
CO4.	Develops ability to analyze Laplace transforms and Inverse Laplace transforms.
CO5.	Evaluate the problems based on Numerical differentiation and Numerical Integration.
CO6.	Develop the ability to create problems and results on Numerical differentiation, Numerical Integration.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Difference Operators, Interpolation: Forward, Backward, Shift, Central, Averaging and Differential Operators, Divided difference Operator, Newton-Gregory Forward and Backward Interpolation Formula, Gauss Forward and Gauss backward Interpolation Formula, Bessel's and Stirling's Interpolation Formula, Newton's Divided Difference Interpolation Formula, Lagrange's Interpolation Formula.	12
II	Solution of Algebraic & Transcendental Equations: Bisection Method, Fixed Point Iteration, Regula Falsi Method, Secant Method, Newton-Raphson Method, Horner's Method, Graffe's Root squaring Method	12

SUGGESTED READINGS:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, 5th Ed, PHI India.
2. Yang, Cao, Chung, Morris, Applied Numerical Methods Using Matlab, John Wiley & Sons, 2007.
3. Anthony Ralston, Philip Rabinowitz, A First Course in Numerical Analysis,Courier Corporation, 2001.

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Skill Enhancement Courses
(Mathematical Modelling)

Course code	:	**MATSC 501**
Course Name	:	**Mathematical Modelling**
Semester /Year	:	**V/3rd**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective:

1. Enable students understand how mathematical models are formulated, solved, and interpreted.
2. Make students appreciate the power and limitations of mathematics in solving practical real-life problems.
3. Equip students with the basic mathematical modeling skills.
4. Create a model that adequately describes the problem, using the appropriate technology if necessary.
5. Test the validity of the model.
6. Solve the problem using the appropriate technology if necessary.
7. Present the results orally, on computer and in a form of a written report.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Identify the vibrations of a mass on a spring.
CO2.	Interpret mixture problem.
CO3.	Examine Vibrating string, vibrating membrane.
CO4.	Evaluate conservation laws problems.
CO5.	Distinguish Vibrating string, vibrating membrane problems.
CO6.	Solve forced motion, resonance phenomena problems.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Applications of differential equations: the vibrations of a mass on a spring, mixture problem.	6
II	Free damped motion, forced motion, resonance phenomena, electric circuit problem, and mechanics of simultaneous differential equations.	6
III	Applications to Traffic Flow. Vibrating string, vibrating membrane.	6
IV	Conduction of heat in solids, gravitational potential, conservation laws.	6

SUGGESTED READINGS:

1. J.N. Kapoor: Mathematical Modelling, Wiley Eastern Ltd, 1982, (Textbook).
2. R. Haberman: Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow, SIAM, 1998, (Textbook)..
3. M. Braun: Differential Equations and their Application: An Introduction to Applied Mathematics, 3rd edition, Springer, 1991.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

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Skill Enhancement Courses
(Differential Geometry)

Course code	:	**MATSC 601**
Course Name	:	**Differential Geometry**
Semester /Year	:	**VI/3rd**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective: Enables students to analyze the equivalence of two curves by applying some theorems. To express definition and parameterization of surfaces. To express tangent spaces of surfaces.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Describe the theory of space curves and plane curves, properties of curves.
CO2.	Explain the fundamental quadratic Forms of surfaces, intrinsic and extrinsic geometry of surfaces, and the Gauss-Bonnet theorem.
CO3.	Solve Tensors, and their properties.
CO4.	Develop the theory of space curves and plane curves.
CO5.	Evaluate intrinsic and extrinsic geometry of surfaces, and the Gauss-Bonnet theorem.
CO6.	Develop the Developable surfaces, Geodesics etc.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves. Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Geodesic mapping. Tissot's theorem.	12
II	Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines. Developable associated with space curves and curveson surfaces, Minimal surfaces.	12

SUGGESTED READINGS:

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

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

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Skill Enhancement Courses
(Finite Field)

Course code	:	**MATSC 701**
Course Name	:	**Finite Field**
Semester /Year	:	**VII/4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective: Enables students to understand the theory of finite fields. Along the way, a bit about field theory more generally.

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Identify and construct examples of fields.
CO2.	Characterize perfect fields using separable extensions, construct examples of automorphism group of a field and Galois extensions as well as prove Artin's theorem and the fundamental theorem of Galois theory.
CO3.	Classify finite fields using roots of unity and Galois theory and prove that every finite separable extension is simple.
CO4.	Use Galois theory of equations to prove that a polynomial equation over a field of characteristic is solvable by radicals iff its group (Galois) is a solvable group and hence deduce that a general quintic equation is not solvable by radicals.
CO5.	Distinguish between algebraic and transcendental extensions.
CO6.	Characterize normal extensions in terms of splitting fields and prove the existence of algebraic closure of a field.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Introduction of Groups, Rings, Fields, irreducible polynomials, roots of irreducible polynomials, primitive polynomials, construction of irreducible polynomials. Introduction to Galois Theory. Finite extensions, characterization of finite fields, Algebraic extensions, roots of polynomials, splitting fields.	12
II	Separable extensions, Normal extensions, Algebraic closure, composite extensions, roots of unity. Cyclotomic Polynomial, cyclotomic extensions and abelian extensions over Q, representation of elements of finite fields.	12

SUGGESTED READINGS:

1. D.S. Dummit and R.M. Foote, Abstract Algebra, John Wiley & Sons Inc., 3rd Ed., 2004.
2. W.W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes. M.I.T. Press, Cambridge, Massachusetts, 1972.
3. S. Lang, Algebra, Springer (India) Pvt. Ltd., 2010.
4. R. Lidl and H. Niederreiter, Introduction to Finite Fields and their Applications, Cambridge University Press, 1994.
5. G.L. Mullen and C.Mummert, Finite Fields and Applications, Student Mathematical library, 41, AMS 2007.
http://www.ams.org/bookstore-getitem/isbn=0-8218-4418-0
6. Khanna, V.K., Bhambri, S.K., A Course in Abstract Algebra, 4th Edition, Vikas Publishing House Pvt. Ltd., 2013.
7. Bhattacharya P.B.,Jain S.K. and Hagpaul S.R., Basic Abstract Algebra Cambridge University Press, Second Edition.
Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

UG Mathematics

Department of Mathematics

Skill Enhancement Courses
(Measure and Integration)

Course code	:	**MATSC 801**
Course Name	:	**Measure and Integration**
Semester /Year	:	**VIII/4th**

Credit distribution of the course	Lecture (L)	Tutorial (T)	Practical (P)	Total
Credit (C)	2	0	0	2
Hours/ week	**2**	**0**	**0**	**2**

Course Objective:

Course Outcome (COs): After completion of this course the student will be able to-

CO1.	Know about the concepts of functions of bounded variations and the absolute continuity of functions with their relations.
CO2.	Understand the requirement and the concept of the Lebesgue integral (a generalization of the Reimann integration) along its properties.
CO3.	Extend the concept of outer measure in an abstract space and integration with respect to a measure.
CO4.	Verify whether a given subset of P or a real valued function is measurable
CO5.	Extend the concept of outer measure in an abstract space and integration with respect to a measure.
CO6.	Demonstrate understanding of the statement and proofs of the fundamental integral convergence theorems and their applications.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Countable sets, uncountable sets, Cardinal numbers of the sets of natural numbers, the set of real numbers and the set of functions, Order relation between these cardinal numbers. Algebra of Cardinal numbers, the extended real numbers, Borel sets, Countably additive measures.	12
II	Lebesgue measure: Outer measure, Measurable sets and Lebesgue measure, Non-measurable sets, Introduction to General Measure and Integration: Measure spaces, Measurable functions Integration. Measurable functions, Littlewood's three principles, Egoroff's Theorem.Lebesgue measure: Outer measure, Measurable sets and Lebesgue measure, Non-measurable sets, Measurable functions, Littlewood's three principles, Egoroff's Theorem.	12

SUGGESTED READINGS:

1.H.L.Royden, Real Analysis, (3rd ed.), The Macmillian Company, New York, 1988.
2. G.de Berra, Introduction to Measure Theory, Van Nostrand Reinhold Company, New York, 1974.
3. R.G. Bartle, The Elements of Integration and Lebesgue Measure, John Wiley & Sons, Inc. New York, 1995.
4. P.K.Jain, V.P. Gupta and P. Jain, Lebesgue Measure and Integration, (2nd ed.), New Age International Publishers, New Delhi, 2011.
5. J.N. McDonald and N.A. Weiss, A Course in Real Analysis, Academic Press, New York, 1999.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

UG Mathematics

Department of Mathematics

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Basic Applied Mathematics

Course code	:	**MATGE101**
Course Name	:	**Basic Applied Mathematics**
Semester /Year	:	**I/ 1st**

L	T	P	C
3	1	0	4

Course Objectives:

The course intends to prepare social science students in the basic concepts and materials from mathematics that necessitate a good foundation to treat basic mathematical models in social science. This course rigorously discusses the basic concepts of logic and set theory, the real and complex number systems, mathematical induction, least upper bound and greatest lower bound, functions and types of functions, polynomial and rational functions, logarithmic and exponential functions, trigonometric functions, hyperbolic functions and their graphs and analytic geometry.

Course outcomes (COs):

Upon successful completion of the course a student will be able to-

CO1	Understand propositional logic and set theory.
CO2	Understand the fundamental properties of real numbers
CO3	Solve equations and inequalities
CO4	Analyze the notion of matrices and determinant.
CO5	Use matrices and determinant to solve system of linear equations
CO6	Solve system of linear equations.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	**Logic.** Definition and examples of proposition, Logical connectives, Compound (or complex) propositions, Tautology and contradiction, Open proposition and quantifiers	15
II	**Set theory.** The concept of a set, Description of sets, Set operations and venn diagrams	15
III	**The real number system.** The natural numbers, Principle of mathematical induction and the Well ordering principle, The integers, rational numbers and irrational numbers, Upper bound and lower bound:least upper bound and greatest lower bound; Solving equation and inequalities; Linear and quadratic equation.	15
IV	**Matrices and Determinant** Definition of a matrix, Algebra of matrices, Types of matrices, Elementary row and column operations, System of linear equations, Definition of a determinant, Properties of determents, Ad joint and inverse of a matrix, Cramer's rule for solving system of linear equations.	15

SUGGESTED READINGS:

4. Timothy M. Hagle, Basic Math for Social Scientists Concepts, SAGE Publications, Inc.
5. A. Shen, Basic set theory Providence, R.I.
6. Robert A. Liebler, Basic Matrix Algebra with Algorithms and Applications, Chapman Hall/CRC Mathematics Series.

Suggested digital platform: NPTEL/SWAYAM/MOOCS

UG Mathematics **Department of Mathematics**

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Applied Calculus

Course code	:	**MATGE201**
Course Name	:	**Applied Calculus**
Semester /Year	:	**II/1st**

L	T	P	C
3	1	0	4

Course Objectives:

The main aim of this course is to learn about applications of derivatives for sketching of curves and conics and applications of definite integrals for calculating volumes of solids of revolution, length of plane curves and surface areas of revolution. Various notions related to vector-valued functions and functions of several variables are discussed in this course.

Course outcomes (COs):

Upon successful completion of the course a student will be able to-

CO1	Learn techniques of sketching the conics.
CO2	Sketch the curves in Cartesian and polar coordinates
CO3	Visualize three dimensional figures.
CO4	Calculate their volumes and surface areas
CO5	Apply concept of higher derivatives
CO6	Calculate complex integrals using reduction formula

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Higher order derivatives, Leibniz rule and its applications to problems.	15
II	Concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves	15
III	Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx\,dx$, $\int \cos nx\,dx$, $\int \tan nx\,dx$, $\int \sec nx\,dx$, $\int (\log x)^n\,dx$, $\int \sin^n x \sin^m x\,dx$.	15
IV	Volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.	15

SUGGESTED READINGS:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer, Verlag, New York, Inc., 1989.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

UG Mathematics

Department of Mathematics

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Numerical Methods

Course code	:	**MATGE301**
Course Name	:	**Numerical Methods**
Semester /Year	:	**III/2nd**

L	T	P	C
3	1	0	4

Course Objectives:
The main aim of this course is to learn about methods and techniques to solve real life mathematical problems numerically. These problems are related to root finding problems, system of algebraic equations, differentiation and integration.

Course outcomes (COs):

Upon successful completion of the course a student will be able to-

CO1	Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and
CO2	Apply methods for solution of a system of linear equations, up to a certain given level of precision.
CO3	Know about methods to solve system of linear equations, such as Gauss–Jacobi, Gauss–Seidel and SOR methods.
CO4	Understand interpolation techniques to compute the values for a tabulated function at points not in the table.
CO5	Applications of numerical differentiation and integration.
CO6	To convert differential equations into difference equations for numerical solutions.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.	15
II	System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.	15
III	Numerical differentiation: Derivatives using Newton's forward interpolation formula, Derivatives using Newton's backward interpolation formula and Derivatives using Stirling's formula. Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.	15
IV	Ordinary Differential Equations: Euler's method. Runge- Kutta methods of orders two and four.	15

SUGGESTED READINGS:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007. 2. M.K. Jain, S.R.K. Iyengar and R.K Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
3. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
4. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

UG Mathematics **Department of Mathematics**

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Graph Theory

Course code	:	**MATGE401**
Course Name	:	**Graph Theory**
Semester /Year	:	**IV/2nd**

L	T	P	C
3	1	0	4

Course Objectives:

The course objectives of Graph Theory are to introduce the students to graphs, their properties and their applications as models of networks. Represent almost any physical situation involving discrete objects and a relationship among them. Introduce the students to generating functions and their applications. Understand fundamentals of graph theory.Study proof techniques related to various concepts in graphs. Explore modern applications of graph theory.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Understand the basics of graph theory and learn about social networks.
CO2	Understand Eulerian and Hamiltonian graphs, diagram tracing puzzles and knight's tour problem.
CO3	Formulate problems in graph theoretic terms
CO4	Understand various versions of connectedness of a graph,
CO5	Formulate applied problems as coloring problems
CO6	Apply different models of random graphs and (random networks).

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Definition, examples and basic properties of graphs, pseudo graphs.	15
II	Complete graphs, bi-partite graphs, isomorphism of graphs.	15
III	Paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path.	15
IV	Dijkstra's algorithm, Floyd-Warshall algorithm. Trees, Properties, Spanning Tee, BFS, DFS.	15

SUGGESTED READINGS:

1. B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory,2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

UG Mathematics **Department of Mathematics**

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Probability and Statistics

Course code	:	**MATGE501**
Course Name	:	**Probability and Statistics**
Semester /Year	:	**V/3rd**

L	T	P	C
3	1	0	4

Course Objectives:

The course objectives of Probability & Statistics are to translate real-world problems into probability models. • To motivate students in an intrinsic interest in statistical thinking. To apply probability and statistics in engineering and science like disease modeling, climate prediction and computer networks etc.

Course outcomes (COs):

Upon successful completion of the course a student will be able to-

CO1	Explain the basic concepts of probability, random variables.
CO2	Solve problems using Baye's theorem.
CO3	Apply probability distributions like Binomial, Poisson, Geometric, Negative binomial, Uniform and Normal distributions
CO4	Understand law of Large numbers, Central limit theorem
CO5	Apply Markov chains concept
CO6	Apply Chapman –Kolmogrov equations to solve statistical problems.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function.	15
II	Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.	15
III	Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.	15
IV	Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance.	15

SUGGESTED READINGS:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Linear Programming

Course code	:	**MATGE601**
Course Name	:	**Linear Programming**
Semester /Year	:	**VI/3rd**

L	T	P	C
3	1	0	4

Course Objectives:

The course objectives of Linear Programming are to describe quantitative methods used in decision making. Describes the process of decision making. Compares the types of quantitative methods. explain the applications of linear programming. Constructs linear programming model. Applies solution methods for linear programming models.

Course outcomes (COs):

Upon successful completion of the course a student will be able to-

CO1	Learn about the graphical solution of linear programming problem with two variables.
CO2	Learn about the relation between basic feasible solutions and extreme points.
CO3	Understand the theory of the simplex method used to solve linear programming problems.
CO4	Learn about two-phase and Big-M methods to deal with problems involving artificial variables.
CO5	Apply sensitivity analysis in linear programming problem. Understand the relationships between the primal and dual problems.
CO6	Solve transportation and assignment problems.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Introduction to linear programming problem (LPP), Formulation of LPP, Graphical method.	15
II	Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison. Sensitivity Analysis, Integer Programming.	15
III	Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.	15
IV	Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.	15

SUGGESTED READINGS:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
4. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

UG Mathematics **Department of Mathematics**

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Advanced Numerical Analysis

Course code	:	**MATGE701**
Course Name	:	**Advanced Numerical Analysis**
Semester /Year	:	**VII/4th**

L	T	P	C
3	1	0	4

Course Objectives:

The course objectives of Advanced Numerical Analysis are to learn state-of-the-art algorithms for solving differential equations. The analysis and implementation of these algorithms will be discussed in some detail.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations.
CO2	Know about methods to solve system of linear equations, such as Gauss–Jacobi, Gauss–Seidel methods
CO3	Apply Interpolation techniques to compute the values for a tabulated function at points not in the table.
CO4	Applications of numerical differentiation and integration
CO5	Convert differential equations into difference equations for numerical solutions
CO6	Verify the level of precision.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	System of Non-linear Equations: Newton's method, Quasi-Newton methods, Broyden's method, Applications-coupled reversible chemical reaction, flow distribution in a pipe flow network.	15
II	Interpolation: Piecewise interpolation, cubic spline interpolation, Hermite interpolation, Hermite cubic interpolation.	15
III	Initial Value Problems: Euler's method, Higher order Tylor's method, Runge-Kutta methods, multistep methods such as Adam-Bashforth and Adam-Moulton methods, Convergence and Stability, Applications-spread of an epidemic, radiative heat transfer to a thin metal plate, geneting switch.	15
IV	Two-Point Boundary Value Problems: Finite difference methods for linear problems with Dirichlet as well as non-Dirichlet boundary conditions, Applications-flow between parallel plates, the heat pack.	15

SUGGESTED READINGS:

1. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, Inc., 2006.
2. K. Atkinson and W.Han, Elementary Numerical Analysis, third Edition, Willey India (P) Ltd., 2004.
3. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Seventh Edition, Pearson Education, Inc., 2004.
4. Froberg C.E., Introduction to Numerical Analysis Addition Wesley, Second Edition, 1969.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

UG Mathematics **Department of Mathematics**

GENERIC ELECTIVE COURSE-(GEC)
COURSE NAME: Advanced Linear Programming

Course code	:	**MATGE801**
Course Name	:	**Advanced Linear Programming**
Semester /Year	:	**VIII/ 4th**

L	T	P	C
3	1	0	4

Course Objectives:

The course objectives of Advanced Linear Programming are to describe quantitative methods used in decision making. describes the process of decision making. Compares the types of quantitative methods. Explain the applications of linear programming. Constructs linear programming model. Applies solution methods for linear programming models.

Course outcomes (COs):

Upon successful completion of the course a student will be able to-

CO1	Appropriately formulate Linear Programming models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these LP problems.
CO2	Apply linear programming method to solve two-person zero-sum game problems.
CO3	Appropriately formulate Network models for service and manufacturing systems
CO4	Appropriately formulate Queuing and Inventory models for service and manufacturing systems.
CO5	Apply operations research techniques and algorithms to solve these Network problems.
CO6	Apply operations research techniques and algorithms to solve these problems.

Course Syllabus:

Unit	Content of Unit	No. of Hours
I	Introduction to LPP (Graphical, simplex, Big-M, Two-Phase, Dual-Simplex methods). Assignment and Transportation Problems, Sequencing problem. Goal programming,	15
II	Game Theory: Two-person zero sum games, game with mixed strategies, graphical solution, and solution by linear programming.	15
III	Inventory, Features of Inventory system, Inventory Model Building, Deterministic Inventory Models with no shortage, Deterministic Inventory with shortage. Probabilistic Inventory Control Models: single period probabilistic model without setup cost-single period probabilities Model with setup cost. Queuing theory.	15
IV	Project Management by PERT/CPM, Network diagram, Rules of construction, Time estimate and critical path analysis, PERT.	15

SUGGESTED READINGS:

1. Kanti-Swarup, P.K. Gupta and man-Mohan, Operations Research, S.Chand publication.
2. G.hadley: Linear Programming, Narosa publishing house 1995.
3. F.S. Hiller and G.J. Lieberman, Introduction to Operations Research (6th Ed.), Mc Graw Hill International Ed., 1995.
4. H.A Taha: Operations Research, An Introduction (3rd Ed.) Macmillan Co., New York, 1982.

Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

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