Savitribai Phule Pune University, Pune

(Formerly, University of Pune)

Four Year (Semester 01 to 08) B.A./B.Sc.

(Honours/Honours with Research)

MATHEMATICS

[F. Y. B. Sc. Sem. 1 & 2:2024 Pattern]
[S. Y. B. Sc. Sem. 3 & 4:2025 Pattern]
[T. Y. B. Sc. Sem. 5 & 6:2026 Pattern]

Syllabus

National Education Policy-2020

To be Implemented From The Academic Year : 2024- 2025

Prepared by : B.O.S. MATHEMATICS, SPPU

Recommended by: Faculty, Science and Technology

Approved by : Academic Council, SPPU

References:

1. videG.R.No.NEP-2022/CRNo.09/VISHI-3/शिकाना,dated 20April,2023.
2. University Circular No. 97, Dated 31 May, 2023.
3. Circular Higher Education, Govt of Maharashtra Dated 13th Mar 2024

(For Colleges Affiliated to Savitribai Phule Pune University, Pune.)

Preamble

The board of studies in Mathematics of Savitribai Phule Pune University, made a rigorous attempt to revise the curriculum of degree program B.Sc. to align it with National Education Policy-2020 and UGC quality mandate for Higher Education Institutions-2021. The process of revamping the curriculum started with the series of meetings, workshops, webinars and discussions with sub-committees conducted by the university to orient the teachers about the key features of the National Education Policy, enabling them to revise the curriculum in sync with the policy. Appropriate orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the policy in the revised curriculum focused on creating holistic, thoughtful, creative and well-rounded individuals equipped with the skill sets of 21^{st} century for the development of an enlightened, socially conscious, knowledgeable and skilled citizen of the nation.

With NEP-2020 in background, the revised curriculum will articulate the spirit of the policy by emphasizing upon integrated approach to learning, innovative pedagogies and assessment strategies, multidisciplinary and interdisciplinary education, creative and critical thinking, student-centric participatory learning, imaginative abilities and flexible curricular structures to enable creative combination of disciplines for the study. The credit structure is followed by university as it is as per the guidelines of state government to design the Degree Program. The curriculum is further modified as per the needs specified in NEP. The curriculum is developed to trigger the inquisitiveness, discussion, analytical ability and quest for discovery among learners.

Mathematics is a powerful tool for understanding and communicate globally that organizes our lives and prevents chaos, which helps us to understand the world and provides an effective way of building mental discipline. Along with mathematical skills, it is also expected that students will learn life skills like argumentation, communication and general social values which are necessary to life rich, productive and meaningful life. Additionally, the knowledge of mathematical modelling and computational training which the students acquire during the Program makes them highly sought after. In keeping with the demands of industry and academia, the syllabus is updated regularly, with inputs taken from various stakeholders including students, alumni and parents at different stages of the modification/addition of the syllabus. The new curriculum provides a synoptic overview of possible career paths mapped by a degree in mathematics teaching, research, engineering, computer programming, statistician, competitive examinations and many more.

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Four Year Degree Program in Mathematics
under the Faculty of
Science and Technology

B.A./B.Sc. (Honours/ Honours with Research)

ABOUT THE PROGRAM:

This B.Sc. Program is uniquely designed to impart essential knowledge in all major areas of pure or applied mathematics. This Program offers an exciting opportunity for specialization in constructing mathematical models for real-life problems and solve them. The program consists of total 08 semesters which are carefully selected blend of theory and practical. It provides feast of mathematical concepts and advanced knowledge in mathematics which are useful to students for specialist professional employment, research in academia and various industries for broader applications. Learner centric curriculum is designed in adherence to the principles of Na- tional Education Policy (NEP 2020) to acquire knowledge and skills with valuable experiences through VSC, SEC, AEC, VEC, IKS, hands-on activities, projects, internships and much more.

OBJECTIVES OF THE PROGRAM:

To prepare the learners, who will understand and apply the basic as well as advanced principles of mathematics for solving problems from science with an emphasis on appli- cations.

To produce the learners who are well-grounded in the fundamentals of mathematics with the acquisition of the necessary skills, tools, and techniques required in many applications areas.

To develop an ability to study the conceptual problem and critically analyze and also promote the use of mathematics in industry and applied sciences.

To provide exposure and motivate students for research in current trends of mathematics.

SCOPE OF THE PROGRAM:

After successful completion of the B.Sc. Program, the learner has ample opportunities to use their mathematical knowledge in different areas:

Career opportunities in government organizations like Defense Research and Development Or- ganization (DRDO), Indian Space Research Organization (ISRO), research laboratories like Council of Scientific and Industrial Research or government owned scientific organizations.

Job positions like Mathematics specialist, Quantitative risk analyst, Treasury management spe- cialist, Public sector banking, Financial institutions, Engineering or Insurance sectors, etc.

Job opportunities in the teaching profession at science and engineering colleges and universities.

Scope for Higher Studies and find lucrative opportunities in the field of research.

PROGRAM OUTCOMES(PO's):

After successful completion of this program, students will be able to

1. enhance their logical thinking and apply advanced mathematical concepts to solve com- plex problems.
2. formulate research questions, design experiments or investigations, collect and analyze data and present their findings in a clear and coherent manner.
3. apply advanced mathematical techniques or tools to analyze and solve challenging prob- lems encountered in mathematics and related fields.
4. formulate mathematical models that represent real-world phenomena, analyze the models using mathematical methods and interpret the results to make informed decisions or predictions.
5. develop proficiency in utilizing computational tools, software and programming languages to aid in mathematical analysis, numerical simulations and data visualization.
6. present complex mathematical concepts, proofs and research findings to both technical and non-technical audiences.
7. develop a strong foundation for professional growth and lifelong learning in Mathematics.
8. acquire lifelong learning skills which will lead important to better opportunities and im- prove quality of life.
9. gain knowledge with the holistic and multidisciplinary approach across the fields.
10. analyzing the results critically and applying acquired knowledge to solve the problems.
11. be independent innovations and published it though research papers and projects.

PROGRAM SPECIFIC OUTCOMES (PSO's):

The student will

1. have a strong foundation for being research in mathematics.
2. be able to apply mathematical skills for solving problems.
3. at least basic knowledge of programming and computational techniques as required for employment.
4. capable to analyze the results critically and apply acquired knowledge to solve the prob- lems.
5. have at least four different skills and capable to think and communicate in three different languages.
6. be able prepare the models for real life problems.

BASIC INFORMATION:

1. **Title of the Program:** B.A./B. Sc. (Mathematics)
2. **Minimum Duration:**
   i) 3 years for B.Sc. Degree- Major in Mathematics.
   ii) 4 years for B.Sc. Honors with Major in Mathematics.
3. **Maximum Program Duration:** 7 years from the date of admission to the program, also referred as valid registration period.
4. **Medium of Instruction:** English
5. **Attendance:** Minimum 75% attendance for all type of courses.
6. **Teaching-Learning:** 15 weeks per semester
7. **Total Credits:** 132 credits for 3 years under graduate degree and 176 credits for 4 years under graduate (Honors) degree. As per UGC norms one credit means 30 hours for practical/lab sessions and 15 hours for theory.
8. **Semester Credits:** 22 credits in each semester.
9. **Continuous Assessment:** Continuous Assessment(CA) will be conducted for continuous evaluation during teaching-learning. 30% weightage may be considered for one or more of the following.
   i) Home assignment(s)
   ii) Seminar/Presentation (individual / group)
   iii) Laboratory Assignment
   iv) Group discussions / Oral
   v) Research paper review
   vi) Technology demonstration using ICT
10. **End Exam:** End Examination (EE) will be conducted for summative evaluation of the student for 70% weightage.
11. **Passing of course:** Min. 40% in CA and EE each.
12. **Eligibility:**

Admission eligibility for the Program	**Degree Certification Eligibility**
HSC/ (10+2) or equivalent from a recognized board **OR** 10+3 Diploma (any stream) awarded by any state board of technical education	Min 40% marks out of total 132 credits at Semesters 01 to 06 for B.A./B.Sc. Mathematics degree **OR** Min 40% marks out of total 176 credits at semesters I to VIII B.A./B.Sc. Mathematics Honours degree.

13. **Rules for A.T.K.T.:** A student who wishes to take admission to the second year (to register for third or fourth semester) of B. A. /B. Sc. (Mathematics) program has to earn at least 22 credits from the total credits of two semesters of the first year of B. A./B.Sc. (Mathematics).

14. **Multiple Entry and Multiple Exit:**

Level of the Program	Entry Option (with criteria)	Exit Option (with criteria)
Certificate Level	HSC (10+2) OR equivalent from the recognized Board OR 10+3 Diploma (any stream) awarded by any state board of technical education	Award of **UG certificate in Mathematics as Major with 44 credits** and an additional 4 credits core NSQF course/ Internship.
Diploma Level	UG Certificate in Mathematics as Major with 40-44 credits	Award of **UG Diploma in Mathematics as Major with 88 credits** and an additional 4 credits core NSQF course/Intern ship
Degree Level	UG Diploma in Mathematics as with 80-88 credits	Award of **UG Degree in Mathematics as Major with 132 credits**

15. **Abbreviation:**

VSC : Vocational Skill Course
IKS : Indian Knowledge System
FP : Field Project
OJT : On Job Training
CEP : Community Engagement and Service
GE/OE : Generic Elective / Open Elective
SEC : Skill Enhancement Course
AEC : Ability Enhancement Course
VEC : Value Education Course
CC : Co-curricular Courses
RP : Research Project
RM : Research Methodology
T : Theory
P : Practical

16. **Note:**

i) VSC, IKS, FP/OJT/CEP should be related to the Major subject.
ii) The Minor subject may be from the different disciplines of the same faculty of Major (Core) or they can be from different faculty altogether.
iii) OE is to be chosen compulsorily from faculty other than that of the Major.
iv) SEC Prepared by BOS or to be selected from the basket approved by university.
v) Wherever require the BOS can choose theory or practical course as per the need and within the given structure.

17. **EXAMINATION RULES:**

(a) A student cannot appear for semester end examination unless he/she has maintained 75% attendance during the teaching period of that course. If a student fails to maintain 75% attendance at the time of filling of examination forms, an undertaking from the student should be taken stating that he/she will be allowed to appear for examination subject to fulfilment of required attendance criteria during the remaining period of teaching of the course.

(b) Each credit will be evaluated for 25 marks Including End Examination (EE) and Continuous Assessment (CA).

(c) Each course of 04 Credits will have semester End Examination (EE) of 70 Marks and Continues Assessment (CA) of 30 Marks while each course of 02 Credit will have semester-end examination of 35 Marks and Continues Assessment of 15 Marks.

(d) To pass a course, the student has to obtain 40% marks for Continuous assessment (CA) and Semester-End Examination (EE) each of these separately.

(e) If any student is not able to appear for internal assessment examination, he/she may be allowed to appear for examination by the permission of higher authorities based on the verification of reason.

(f) Students who fail to score passing marks in semester-end exam/Continues Assessment may appear for the semester-end exam/ Continuous Assessment in the subsequent period but within allotted period for Program. The allotted period for two, three and four year degree programs is four, five and seven years respectively.

(g) A student cannot register for the subsequent year unless he/she achieves 50% credits of the total credits expected to be ordinarily completed for that particular year. The student can seek admission to third year only after achieving 100% Credits of the first year as well the student seeking admission to fourth year should achieve 100% Credits of second year.

(h) There shall be revaluation of the answer scripts of semester-end examination but not of internal assessment and Practical Examination.

(i) Even though the marks will be given for all examinations, they will be converted into grades. The semester end and final mark sheets and transcripts will have only grades and grade points average.

(j) Continuous Assessment of each Course will have weightage of 30% of marks and a teacher must select at least three components for the examination from the following

i) Written Test / Mid Term Test/ An Open Book Test
ii) Seminar/ Group discussion.
iii) Journal/Lecture/Library notes.
iv) PPT or poster Presentation.
v) Short Quizzes.
vi) Assignments
vii) Mini Research Project
viii) Field visit/ Industrial visit

(k) Evaluation of OJT/FP/RP/RM will be done during practical Examination through external examiners by dissertation, Presentation, Oral, Field work project report, etc.

Board of Studies in Mathematics, Savitribai Phule Pune University, Pune

Proposed Credit Structure for Level 4.5-8 as per Govt. of Maharashtra through Circular Higher Education, Govt. of Maharashtra Dated 13th March, 2024

Year/ Level	Sem.	Subject- I				Subject- II	Subject- III	V-3	V-5	V-4	V-5	V-5	V-6	V-6	Total
								OE/GE	IKS	SEC	AEC	VEC	CC	RP	
1 Yr./4.5	I	2(T)+2(T/P)=4 **MTS-101-T :**Algebra and Calculus-I (2T) **MTS-102-P:** Practical Based on MTS-101(2P)	--	_	_	2(T)+2(T/P)=4	2(T)+2(T/P)=4	2(T/P) OE 101 MTS: (other Faculty)	2 IKS 101 MTS: Generic IKS	2 SEC-101MTS Python-I (P)	2 AEC-101ENG: English Communication	2 VEC101 ENV: Environmental Studies	_	_	22
	II	2(T)+2(T/P)=4 **MTS-151-T :**Algebra and Calculus-II (2T) **MTS-152-P :**Practical Based on MTS-151(2P)		_	_	2(T)+2(T/P)=4	2(T)+2(T/P)=4	2(T/P) OE 151 MTS: (other Faculty)	-	2 SEC-151MTS Python-II (P)	2 AEC-151 ENG: English Communication	2 VEC151 ENV: Environmental Studies	2 CC151 (PE/NSS /NCC)	_	22
Students will Select One Subject Among the (Subject 1, Subject 2, Subject 3) as Major and another as Minor and third Subject will be dropped															
		Major	**Elective**	**VSC**	**OJT/FP /CEP**	**Minor**	**-**	**OE/GE**	**IKS**	**SEC**	**AEC**	**VEC**	**CC**	**RP**	22
		V-1		**V-4**	**V-6**	**V-2**		**V-3**	**V-5**	**V-4**	**V-5**	**V-5**	**V-6**	**V-6**	
2 Yr./5.0	III	4(T)+2(P)=6 **MTS-201MJ:** Calculus of Several Variables(T) **MTS-202MJ:** Laplace Transforms and its Applications(T) **MTS-203 MJP:** Practical Based Calculus of Several Variables and Laplace Transforms (P)	--	2(T) **MTS-221VSC** Foundation Mathematics	2(P) MTS-231 FP	2(T)+2(P)=4 MTS 241 MN (A/B/C) &MTS 242 MN (A/B/C)	-	2 (T) OE 201 MTS: (other Faculty) (A/B/C)	2(T) IKS 101 MTS: IKS Subject	-	2(T) AEC-201: MIL :ENG/MAR/HIN(T)	_	2 CC201 (PE/NSS /NCC)		

	IV	4(T)+2(P)=6 **MTS-251MJ:** Linear Algebra(T) **MTS-252 MJ:** Vector Calculus (T) **MTS-253MJP :** Practical on Linear Algebra and Vector Calculus (P)	--	2 **MTS-271VSC** R-Programming (P)	2 MTS-281 CEP	2(T)+2(P)=4 MTS 291 MN & MTS 292 MN (A/B/C)	-	2(T) OE 251 MTS: (other Faculty) (A/B/C)		2(P) SEC-251MTS: Latex	2 AEC-251: MIL :ENG/MAR/HIN(T)	_	2 CC251 (PE/NSS /NCC)		22
3 Yr./5.5	**V**	8(T)+4(P)=12 **MTS-301 MJ:** Metric Spaces **MTS-302 MJ:** Real Analysis-I **MTS-303 MJP:** Practical on Metric Spaces &Real Analysis-I **MTS-304 MJ:** Group Theory (T) **MTS-305 MJ:** Ordinary Differential Equations **MTS-306 MJP** : Practical on Group Theory and ODE	2(T)+2(P)=4 **MTS-310 MJ:** A) Graph Theory (T) OR B) Linear Programing Problem and Game Theory(T) **MTS-311 MJP:** A) Practical on Graph Theory B) Practical on Linear Programing Problem and Game Theory	2 **MTS-321 VSC:** Mathematical Statistics (P)	2 MTS-331 FP:	2(T) MTS 341 MN A) Integral Transform B) Operation Research	-								22

	VI	8(T)+4(P)=12 **MTS-351 MJ**: Complex Analysis **MTS-352 MJ** : Real Analysis –II **MTS-353 MJP:** Practical on Complex Analysis and Real Analysis-II **MTS-354 MJ:** Ring Theory (T) **MTS-355 MJ**: Partial Differential Equations **MTS-356 MJP**: Practical on Ring Theory & PDE	2(T)+2(T/P) =4 **MTS-360 MJ**: A) Numerical Methods (T) OR B. Computational Geometry (T) **MTS-361 MJP:** A) Practical on Numerical Methods (P) B) Practical on Computational Geometry(P)	2(P) **MTS:371 VSC** Data Science (P)	4(P) MTS-381 OJT:	-	-								22
Total		**44**	**8**	**8**	**10**	**18**	**8**	**8**	**4**	**6**	**8**	**4**	**6**		**132**
4 Yr./6.0	**VII**	6(T)+4(P)=10 **MTS -401 MJ:** Linear Algebra(T) **MTS-402 MJP:** Practical Based on MTS-401 (P) **MTS -403 MJ:** Group Theory **MTS -404 MJ:** Ordinary differential Equations **MTS -405 MJP:** Programming with Python(P)	2T)+2(T/P)=4 **MTS-410MJ :** A) Advanced Numerical Analysis OR B)Number Theory OR C) Combinatorics OR D)Lattice Theory **MTS-411 MJP:** Practical based on (A /B/C/D)			**4 RM**								4 MTS -481 OJT:	22

Hon. With Research	**VIII**	6(T)+4(P)=10 **MTS- 451 MJ:** Topology (T) **MTS- 452 MJ:** Practical Based on MTS-451 (P) **MTS- 453 MJ:** Ring Theory(T) **MTS- 454 MJ:** Advanced Calculus(T) **MTS- 455 MJ:** Data Science(P)	2T)+2(T/P)=4 **MTS-460 MJ** A)Graph Theory OR B)Dynamical Systems OR C) Coding Theory OR D)Operation Research **MTS-461 MJP:** Practical based on MTS 460 (A/B/C/D)											8 MTS -481 RP:	22
Total		**64**	**16**	**8**	**10**	**22**	**8**	**8**	**4**	**6**	**8**	**4**	**6**	**12**	**176**

Savitribai Phule Pune University

(Formerly University of Pune)

Four Year Graduate Degree Programme in Mathematics

(Faculty of Science & Technology)

New

Syllabi for

F. Y. B. A. / B. Sc. - Mathematics

(For Colleges Affiliated to Savitribai Phule Pune University, Pune)

(As per National Education Policy- 2020)

To be implemented from the Academic Year 2024-2025

Syllabus for F.Y.B.Sc. as per NEP-2020
Subject: Mathematics

Semester - I

MTS 101-Algebra and Calculus I

Course type: Theory **No. of Credits: 02**

Course Objectives: This course aims

1. To provide a first approach to Algebra, a basic pillars of mathematics.
2. To cover the basic knowledge of integers and polynomials.
3. To study the theory of integers and polynomials.
4. To establish the fundamental theorem and applications of single variable functions.
5. To understand real numbers and its properties.
6. To understand the concept of limiting process, and continuity in terms of limit.
7. To develop mathematical thinking and skills.

Course Outcomes: The student will able

1. To know the concept of divisibility in integers.
2. To find Greatest Common Divisor of integers using the Euclidean algorithm.
3. To understand the concept of Fermat's theorem and Euler's phi function.
4. To understand the method of finding roots of polynomials and relationship between roots and coefficients of a polynomial.
5. To classify real numbers and recognize various properties of real numbers.
6. To understand the concept of limit and continuity.
7. To draw the graphs of algebraic and transcendental functions considering limits and continuity.
8. To apply the concept of limit and continuity for advanced study of different mathematics courses, and in physical, chemical and biological sciences.

Course Content

Section I: Algebra
Unit 1: Integers **(09 Hours)**

1.1 Well Ordering Principle and Principle of Mathematical Induction (First Principle).

1.2 Divisibility in integers ($\mathbb{Z}$) -Definition and elementary properties, Division algorithm, Greatest Common Divisor (GCD), Least Common Multiple (LCM) of integers, basic properties of GCD, Euclidean Algorithm, relatively prime integers.

1.3 Prime numbers- Definition, fundamental theorem of Arithmetic, Euclid's lemma, Theory of Congruences, basic properties, Fermat's theorem, Euler's phi function, Euler's theorem.

Unit 2: Polynomials **(06 Hours)**

2.1 Definition of a polynomial, degree of a polynomial, algebra of polynomials, division algorithm (Statement only) and examples, Greatest Common Divisor (GCD) of two polynomials (Definition and examples).

2.2 Synthetic division, Remainder theorem, Factor theorem.

2.3 Relation between roots and co-efficient of a polynomial.

Reference Books:

1. Elementary Number Theory, David M. Burton, Tata McGraw Hill, Seventh Edition. Chapter 1: Sec. 1.1, Chapter 2: Sec. 2.2, 2.3,2.4, Chapter 3: Sec. 3.1, Chapter 4:Sec. 4.2, Chapter 5: Sec. 5.2 up to corollary on Theorem 5.1, Chapter 7: Sec. 7.2 only definition, Section 7.3, lemma and Theorem 7.5.

2. Theory of Equations, J. V. Uspensky, McGraw Hill Book Company. Chapter 2, Chapter 3: Sec. 5

3. Textbook of Algebra, S. K. Shah and S. C. Garg, Vikas Publishing House Pvt. Ltd. Edition 2017.

Section II: Calculus

Unit 3: Real Numbers **(06 Hours)**

3.1 Number system - $\mathbb{N}$,$\mathbb{Z}$,$\mathbb{Q}$,$\mathbb{R}$, Algebraic and Order properties of $\mathbb{R}$.

3.2 Absolute Value of a real number, geometrical meaning, Absolute value properties of $\mathbb{R}$, triangle inequality, examples on absolute value of $\mathbb{R}$.

3.3 Boundedness of $\mathbb{R}$ -Neighborhood of a point on real line, Intervals, Lower bound, Upper bound and examples, Well Ordering Principle of $\mathbb{N}$, Supremum and Infimum of a subset of $\mathbb{R}$ and examples, Completeness property of $\mathbb{R}$.

Unit 4: Limits and Countinuity **(09 Hours)**

4.1 Limit of Real valued function-Definitions and examples, Algebra of limits and examples.

4.2 Limit theorems- Squeeze theorem and some results, one sided limits and limits at infinity and examples.

4.3 Continuity - Definition of deleted neighborhood of a point, Continuity of a function at a point - Definitions and examples, Algebra of continuous functions, properties, Continuity on an interval - Definition and examples, Bounded function, Boundedness theorem (Statement only), Absolute maximum and minimum of a function - definition, Maximum-Minimum theorem (statement only), Location of roots theorem statement only), Bolzano's theorem (statement only) the intermediate value theorem

Text Books:

1. Calculus, Vol. I: One Variable Calculus with an Introduction to Linear Algebra- Tom M. Apostol, Second Edition, Reprint 2011, Wiley Students Edition, John Wiley and Sons Inc., U.K

(a) Introduction Part 3: 1.3.1, 1.3.2, 1.3.4, 1.3.7, 1.3.8, 1.3.13 (without Theorem 1.3.5), 1.4.3, 1.4.8 (Theorem 1.3.8, Theorem 1.3.9, Theorem 1.4.0)

(b) Chapter 3: 3.2, 3.3, 3.4, 3.5 - Theorem 3.2, Theorem 3.3, Theorem 3.4, Theorem 3.6, Theorem 3.7, Theorem 3.8, Theorem 3.10, Theorem 3.11 (without proof), Theorem 3.12.

Reference Books:

1. Introduction to Real Analysis - R. G. Bartle and D. R. Sherbert, Third Edition, John Wily and Sons, Inc.

   (a) Chapter 1: Section 1.2 - 1.2.1, 1.2.2, 1.2.3.

   (b) Chapter 2: Section 2.1: 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.1.7 Theorem), 2.1.8 (Theorem), 2.1.9 (Statement only), 2.1.10 (Theorem), 2.1.11, 2.1.12, 2.1.13. Section 2.3: 2.3.1, 2.3.2, 2.3.3, 2.3.6, 2.4.3, 2.4.8, 2.4.9.

2. Differential Calculus- Shantinarayan Tenth Revised Edition

3. Introduction to Real Analysis - William F. Trench, Free Edition, 2010.

4. Calculus of single Variable - Ron Larson, Bruce Edwards, Tenth Edition.

5. Elementary analysis: the theory of Calculus - Kenneth A. Ross, Second Edition, Springer Publication.

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MTS 102 - Practicals based on MTS-101 (Algebra and Calculus I)

Course type: Practical **No. of Credits: 02**

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IKS 101 MTS: Generic IKS

Course type: IKS **No. of Credits: 02**

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SEC-101 MTS: Python-I

Course type: SEC **No. of Credits: 02**

Course Objectives: This course aims

1. To know about python IDE.
2. To write, test, and debug simple Python programs.
3. To implement Python programs with conditionals and loops statements.
4. To understand the syntax of strings in Python.
5. To understand the concept of function.
6. To understand the concept of list, tuples and its operation.

Course Outcomes: The student will able

1. To write python programs and develop a small application.
2. To develop logic for problem solving.
3. To be familiar about the basic constructs of programming such as data, operations, conditions, loops, functions etc.
4. To be familiar with string and its operation.
5. To develop basic concepts of function and terminology.
6. To determine the methods to create and develop Python programs by utilizing the data structures like lists and tuples.

Course Content

Unit 1: : Python Basics and IDE **(04 Hours)**

1.1 Introduction of Python.

1.2 Installing Python

1.3 Running Simple Program.

1.4 Removing Keys.

1.5 Traversing a Dictionary

- Practical 1 based on unit 1.

Unit 2: Basics of Python **(08 Hours)**

2.1 Data type of Python.

2.2 Variable declaration rule.

2.3 Python Identifier and reserved words.

2.4 Input Output Function.

2.5 Operator of Python.

2.6 Advanced Python operator(Membership and identity).

2.7 Comments in Python.

2.8 Line and Indentation.

- Practical 2, Practical 3 based on unit 2.

Unit 3: Conditional structure **(08 Hours)**

3.1 if Statements

3.2 if -else and statement

3.3 Nested if

3.4 if-elif-else ladder

- Practical 4 and Practical 5 based on unit 3.

Unit 4: Iteration statement **(12 Hours)**

4.1 Loop Control Structure.

4.1.1 While loop

4.1.2 For loop

4.2 Nested loop

4.3 Break Statement

4.4 Continue Statement

4.5 Pass Statement

- Practical 6, Practical 7 and Practical 8 based on unit 4.

Unit 5: String and Function **(12 Hours)**

5.1 String Basics.

5.2 Accessing and updating String.

5.3 Built-in String Methods.

5.4 Function in Python.

5.5 Declaration and Calling function.

5.6 Function Argument

5.7 Anonymous Functions

- Practical 9, Practical 10 and Practical 11 based on unit 5.

Unit 6: List and Tuple **(16 Hours)**

6.1 Python Lists.

6.2 Accessing and updating List.

6.3 Basic List Operation.

6.4 Built-in List Methods.

6.5 Python Tuple.

6.6 Accessing and updating tuple.

6.7 Basic tuple operation.

6.8 Built-in tuple Method.

- Practical 12 to Practical 15 based on unit 6.

Reference Books:

1. Fundamentals of Python first programs, 2nd Edition, Kenneth A. Lambert.
2. Beginning Python from Novice to Professional, Third Edition, Magnus Lie Hetland.
3. Python for Science and Engineering, Hans-Petter Halvorsen.
4. Python Programming: An Introduction to Computer Science, Third Edition, John Zelle.
5. Introduction to Scientific Computing in Python, Continuum Analytics and Robert Johansson.

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Semester - II

MTS-151:Algebra and Calculus II

Course type: Theory **No. of Credits: 02**

Course Objectives:

1. To study matrix properties, algebraic properties, and methods for finding the inverse of a matrix.
2. To explore the solution of systems of linear equations and evaluate determinants by row reduction.
3. To learn the properties of determinants and study the applications of matrices and determinants.
4. To learn how to find the derivative of a function using limits, and understand the geometrical and physical significance of derivatives.
5. To explore methods to find the n^{th} derivatives of functions.
6. To generalize the comprehensive study of combined algebra and calculus.

Course Outcomes: The successful completion of these course students will able to:

1. Understand the various types of matrices, their properties, and how to convert matrices to echelon form using elementary row operations.
2. Learn methods to solve systems of linear equations, understand the concept of determinants, evaluate determinants by different methods, and solve problems using properties of determinants.
3. Apply the concept of matrices and determinant to the problems in chemistry, electronics, cryptography, etc.
4. Understand differentiation and fundamental theorem in differentiation.
5. Apply Mean Value Theorems and it's applications
6. Explore the combined application of algebra and calculus to various mathematical problems.

Course Content

Unit 1 : Systems of Linear Equations and Matrices: (08 Hours) Section I: Matrix Algebra

1.1 Matrices and Matrix Operations.

1.2 Inverses; Algebraic Properties of Matrices

1.3 Elementary Matrices and a Method for Finding A^{-1}

1.4 Matrix, Matrix Notation and Size of Matrix.

1.5 Diagonal, Triangular, and Symmetric Matrices [Definitions and examples only]

1.6 More on Linear Systems and Invertible Matrices

1.7 Introduction to Systems of Linear Equations

1.8 Gaussian Elimination Method.

Note: Theorems 1.4.1,1.4.3,1.4.8,1.5.3,1.6.1-1.6.4,1.7.1 are without proof.

Unit 2: Determinants (07 Hours)

2.1 Determinants by Cofactor Expansion.

2.2 Evaluating Determinants by Row Reduction.

2.3 Properties of Determinants; Cramer's Rule (Without Proof).

2.4 Applications towards Balancing Chemical Equations.

2.5 Applications in Cryptography.

Note: Theorems 2.1.1, 2.1.2, 2.2.3, 2.2.4, 2.3.1, 2.3.6, 2.3.8 are without proof

Recommended book:

1. Elementary Linear Algebra by Howard Anton, Chris Rorres, 11th Edition [Applications Version] Unit 1: Section 1.1 to 1.7 , Unit 2: Section 2.1 to 2.3, 2.4 [1.10 Balancing Chemical Equations]

Reference Books:

1. Matrix and Linear Algebra by K. B. Datta, Prentice Hall India Pvt., Limited, 2004.
2. Fundamentals of Matrix Algebra, (3rd Edition) by G. Hartman
3. Linear Algebra and its Applications, David Lay, Third Edition, Pearson Publications.

Section II: Calculus

Unit 3: Differentiation (06 Hours)

3.1 The Derivative as a Function.

3.2 Differentiation Rules

3.3 The Derivative as a Rate of Change

3.4 Derivatives of Trigonometric Functions

3.5 The Chain Rule

3.6 Applications

Unit 4: Mean Value Theorems (09 Hours)

4.1 Extreme Values of Functions.

4.2 The Mean Value Theorem

4.3 L$'$Hospital$'s$ Rule (without proof)

4.4 Cauchy's Mean Value Theorem

Recommended book:

1. Applied Finite Mathematics by R. Sekhon and R. Bloom, Libre Texts. Unit 2 (2.5): Section 2.5
2. Thomas Calculus: EARLY TRANSCENDENTALS (12th Edition), Pearson Education Unit 3: Section 3.2 - 3.6 and 3.10 Unit 4: Section 4.1 - 4.2 and 4.5

Reference Books:

1. Calculus Volume I (Second Edition) Wiley Student Edition, T. M. Apostol, John Wiley, New Delhi.
2. Elements of Real Analysis, Shanti Narayan, M. D. Raisinghaniya (Revised Edition 2012), S. Chand and Company Ltd.

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MTS 152 - Practicals based on MTS-151 (Algebra and Calculus II)

Course type: Practical **No. of Credits: 02**

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SEC-151 MTS Python-II

Course type: SEC **No. of Credits: 02(P)**

Course Objectives:

1. To give students an advanced introduction to Programming.
2. To learn and understand Python programming and paradigm.
3. To implement python program with dictionary and turtle
4. To understand the concept of 2D graphics
5. To understand the concept of files
6. To prepare the program for matrix and operations on it.

Course Outcomes:

1. To write python program and develop maps using dictionary
2. To develop logic for 2D graphics.
3. Demonstrate the use of Python in mathematics such as matrix algebra
4. To be familiar about basic math built in functions such as sine, cosine, etc.
5. To be familiar with complex numbers
6. To write Python programs to handle matrices and vectors using NumPy.

Course Content

Unit 1: Dictionaries **(08 Hours)**

1.1 Dictionary Literals

1.2 Adding Keys and Replacing Values

1.3 Accessing Values

1.4 Removing Keys

1.5 Traversing a Dictionary

-Practical 1 and Practical 2 based on unit 1.

Unit 2: Simple Graphics **(12 Hours)**

2.1 Overview of Turtle graphics

2.2 Turtle operations

2.3 Setting up a turtle.cfg file and running IDLE.

2.4 Object instantiation and the turtle module

2.5 Drawing two dimensional shapes

2.6 Examining an object's attributes

2.7 Manipulating a Turtle's screen

2.8 Taking a random walk

2.9 Colours and the RGB system

-Practical 3, Practical 4 and Practical 5 based on unit 2.

Unit 3: Complex Numbers in Python **(08 Hours)**

3.1 Introduction to complex numbers

3.2 Complex numbers with Python

-Practical 6 and Practical 7 based on unit 3.

Unit 4: File Handling **(08 Hours)**

4.1 Opening Files: File Modes

4.2 The basic file methods

- 4.2.1 Reading and Writing
- 4.2.2 Piping output
- 4.2.3 Reading and writing lines
- 4.2.4 Closing files
- 4.2.5 Using the basic files methods

4.3 Iterating over file content

- 4.3.1 One character at a time
- 4.3.2 One line at a time
- 4.3.3 Reading everything
- 4.3.4 Lazy line iteration with file input
- 4.3.5 File iterators

-Practical 8 and Practical 9 based on unit 4.

Unit 5: NumPy **(12 Hours)**

5.1 NumPy basics

5.2 NumPy arrays

5.3 Copying / Sorting

5.4 Array manipulation.

5.5 Mathematics

5.6 Basic Statistics

-Practical 10, Practical 11 and Practical 12 based on unit 5.

Unit 6: Matrix Algebra in Python **(12 Hours)**

6.1 Vectors

6.2 Matrices

6.3 Linear Algebra

6.4 Matrix addition

6.5 Matrix subtraction

6.6 Matrix multiplication

6.7 Transpose of a matrix.

6.8 Determinant.

6.9 Inverse matrix

- Practical 13 and Practical 14 based on unit 6.
- Practical 15 is based on unit 5 and 6.

Reference Books:

1. Fundamentals of Python first programs, 2nd Edition, Kenneth A. Lambert.
2. Beginning Python from Novice to Professional, Third Edition, Magnus Lie Hetland.
3. Python for Science and Engineering, Hans-Petter Halvorsen.
4. Python Programming: An Introduction to Computer Science, Third Edition, John Zelle.
5. Introduction to Scientific Computing in Python, Continuum Analytics and Robert Johansson.

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[Open Electives for the Students other than Faculty of Science]
OE-101 MTS : Basic Mathematics- I

Course type: OE(T) **No. of Credits: 02**

Course Objectives:

1. To understand basic concepts of Mathematics.
2. To be able to use the language, symbols, and notation of Mathematics.
3. To develop Mathematical curiosity and acquire skills in problem solving.
4. To develop an appropriate understanding of how to use mathematics in real-world problems.
5. To cultivate the right understanding and regain numerical aptitude.
6. To develop a logical approach toward analytical approach data.

Course Outcomes: The student will able

1. To understand the concepts of numbers and integers and able to develop skills in basic operations of integers to cultivate the right understanding and regain numerical aptitude.
2. To understand concepts of H.C.F. and L.C.M. of numbers, square root and cube Root and ability to apply in real-world problems.
3. To understand concepts of ratio, proportion, percentage and be able to cultivate the right understanding regaining numerical aptitude.
4. To understand concepts of average, profit and loss develop a logical approach toward analytical approach to real-world problems
5. To provide a platform for the students to build the fundamentals of Basic Mathematics for competitive examination preparation strategy
6. To establish a framework for the students to help acquire the knowledge and expertise necessary to secure employment opportunities in the government sector

Course Content

Unit 1: Integers **(12 Hours)**

1.1 Introduction to number system, Basic operations of integers

1.2 Highest Common Factor (H.C.F.) and Least Common Multiple (L.C.M.)

1.3 Square root and cube Root

Unit 2: Ratio, Proportion and Percentage **(08 Hours)**

2.1 Introduction to ratio and proportion

2.2 Finding ratio and proportion

2.3 Types of ratios

Unit 3: Average **(04 Hours)**

3.1 Introduction to average

3.2 Finding the average

Unit 4: Profit and Loss **(06 Hours)**

4.1 Introduction to profit and loss

4.2 Finding profit and loss

Reference Book:
Quantitative Aptitude for Competitive Examination by Dinesh Khattar, Pearson India Education Services Pvt. Ltd., Fourth Edition.

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OE-102 MTS: Applied Mathematics - I

Course type: OE(P) **No. of Credits: 02(P)**

Course Objectives:

1. To develop a strong understanding of Geometry.
2. To becomes Master of basic operations on numbers in different way.
3. To gain proficiency in working with Profit and loss.
4. To acquire a solid foundation of trigonometry.
5. To learn the simulation of data.
6. To develop problem-solving skills by applying operations.

Course Outcomes: The student will able to

1. Enhance mathematical reasoning and critical thinking.
2. Easily present the data graphically.
3. Have the knowledge of geometrical shapes and their equations.
4. Have Skills of comparison through diagrams and charts.
5. Got the business ability.
6. Achieve the techniques of finding area and volume.

Course Content

Unit 1: Mensuration **(08 Hours)**
Perimeter of circle, triangle, square and rectangle. Area of circle, square, rectangle and triangles. Surface area of cylinder, sphere, cube and cuboid. Volume of cube, cuboid, sphere, hemisphere, cylinder and cone.

Unit 2: Trigonometry **(08 Hours)**
Degree and radian, Trigonometric ratios and identities, Angle of elevation and depression, Height and distance problems.

Unit 3: Arithmetic **(08 Hours)**
Arithmetic Mean, Geometric Mean, Harmonic Mean, Ratio, Proportion, Percentage, Profit and Loss, Partnership, Brokerage, (True) Discount, Simple and Compound Interest, Time and Work, Distance

Unit 4: Data Interpretation **(06 Hours)**
Tabulation, missing data problem. Graphs and Charts - Table, Line, Bar and Pie.

Reference Books:

1. Objective Arithmetic, R S Aggarwal, S. Chand & Company Ltd.
2. Business Mathematics,S. K. Sharma and G. Kaur, Sultan Chand & Sons.
3. Business Mathematics-II Edition Q. Zameerddin, V. K. Khanna, S K Bhambri.

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OE-151 MTS: Basic Mathematics - II

Course type: OE(T) **No. of Credits: 02**

Course Objectives:

1. To be able to use the language, symbols and notation of Mathematics.
2. To develop Mathematical curiosity.
3. To help them acquire skills in solving problems.
4. To develop an appropriate understanding of how to use mathematics in real-world problems.
5. To cultivate the right understanding and regain numerical aptitude.
6. To develop a logical approach toward analytical approach data.

Course Outcomes: The student be will able

1. To understand the concepts of Time, Work and Wages also be able to logical approach towards analytical approach data of real word problem
2. To understand concepts of Linear Equations and ability to solve examples in finding Age in past and future.
3. To understand concepts of Simple and Compound Interest and to develop Mathematical Competence.

4. To understand concepts of Mensuration and able to develop Mathematical competence in solving Problems.
5. To provide a platform for the students to build the fundamentals of Basic Mathematics for competitive examination preparation strategy.
6. To establish a framework for the students to help acquire the knowledge and expertise necessary to secure employment opportunities in the government sector.

Course Content

Unit 1: Time, Work and Wages **(12 Hours)**

1.1 Introduction to Time, Work and Wages

1.2 Finding Time and Amount of Work

1.3 Finding Speed, Distance and Time

1.4 Finding Speed of Boats and Stream

Unit 2: Problems on Ages **(06 Hours)**

2.1 Introduction to Linear Equations

2.2 Finding Age Some Years Ago, Present Age and Age Some Years hence

Unit 3: Simple Interest and Compound Interest **(06 Hours)**

3.1 Introduction to Simple Interest and Compound Interest

3.2 Finding Simple Interest

3.3 Finding Compound Interest

Unit 4: Mensuration **(06 Hours)**

4.1 Introduction to the Concept of Mensuration

4.2 Finding Area, Perimeter, and Some Basic Facts

4.3 Introduction to Solids and Cubes

4.4 Finding Surface Area and Volume

Reference Book:

Quantitative Aptitude for Competitive Examination by Dinesh Khattar, Pearson India Education Services Pvt. Ltd., Fourth Edition.

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OE-152 MTS: Applied Mathematics - II
Title : Introduction to MS Excel

Course type: OE(P) **No. of Credits: 02(P)**

Course Objectives: This course aims on

1. Basic Essential Computing skills companies are looking for.
2. Hands-on Practical Knowledge.
3. Boosting their resume.
4. Providing an edge over other applicants in the competitive job market.
5. Providing valuable experience and confidence.
6. Heightening their earning potential.

Course Outcomes: The student will be able to

1. Create, save and print worksheets
2. Create formulas
3. Use functions for SUM, AVERAGE, MIN, and MAX
4. Use the function for IF
5. Format cells using many of the formatting tools
6. Present the Data Graphically

Course Content

Practical 1: The Excel environment
Navigating a worksheet
Spreadsheet terminology
Getting help

Practical 2: Entering and editing data
Entering and editing text and values
Entering and editing formulas
Saving and updating workbooks

Practical 3: Modifying a worksheet
Moving and copying data
Moving and copying formulas
Inserting and deleting ranges, rows, and columns
Cell comments

Practical 4: Using functions
Entering functions
AutoSum
Other common functions

Practical 5: Formatting
Text formatting
Row and column formatting
Number formatting
Conditional formatting
Additional formatting options

Practical 6: Printing
Preparing to print
Page Setup options
Printing worksheets

Practical 7: Charts
Chart basics
Column Chart
Pie Chart
Bar Chart
Pai Chart
Line Chart

Practical 8: Case Study
Modifying existing worksheet
Use shortcut keys
Create and email worksheet

Practical 9: Review Basics
Downloading from Account Reconciliation
The Excel environment
The Sparkline
The Trendline

Practical 10: Subtotal Functions
Create an outline and consolidate data
Create subtotals in a list
Use multiple subtotal functions- SUBTOTAL, SUMIF
Create custom views to save different sets of worksheet display and print settings

Practical 11: Range names and Filter date
Define and apply cell and range names
Use names in Formulas
Filter data based on complex criteria
Use conditional filters
Copy filtered results to another range

Practical 12: Pivot Tables
Prepare data in a table format and name the table
Create a PivotTable for analysing
Use the Download Actuals page in Account
Reconciliation as example
Modify or re-arrange fields

Practical 13: Selected Functions
Using IF and SUMIF functions to calculate a value based on specified criteria
Use ROUND function to round off numbers
Use VLOOKUP to find values in worksheet data
Use HLOO

Practical 14: Simulation
Scatter
Area
Stock
Surface
Rader

Practical 15: Applications
Applications of Ms-excel
business analysis
data entry and storage
data analysis
accounting and budgeting

Reference Book:

Beginning Excel 2019 by Noreen Brown; Barbara Lave; Hallie Puncochar; Julie Romey; Mary Schatz; Art Schneider; and Diane Shingledecker
Open Oregon Educational Resources

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Savitribai Phule Pune University

(Formerly University of Pune)

Four Year Graduate Degree Programme in Mathematics

(Faculty of Science & Technology)

New

Syllabi for

S. Y. B. A. / B. Sc. - Mathematics

(For Colleges Affiliated to Savitribai Phule Pune University, Pune)

(As per National Education Policy- 2020)

To be implemented from the Academic Year 2025-2026

Syllabus for S.Y.B.Sc. as per NEP - 2020
Subject: Mathematics

Semester - III

MTS-201-MJ: Calculus of Several Variables

Course type: Major **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Define and analyze functions of several variables.
2. Evaluate limits and continuity of multivariable functions using various techniques.
3. Compute first and higher-order partial derivatives of multivariable functions.
4. Determine extrema of functions using the second derivative test and Lagrange multipliers.
5. Compute double and triple integrals in Cartesian, polar, cylindrical, and spherical coordinates.
6. Apply multiple integrals to calculate areas, volumes, mass, and density.

Course Content

Unit 1: Limits and Continuity **(06 Hours)**

1.1 Functions of Several Variables: Definition, domain, range, level curves, graphs

1.2 Limits of Functions of Several Variables: Definition, evaluating limits along different paths

1.3 Techniques to Evaluate Limits: Direct substitution, Path approach, Squeeze theorem

1.4 Continuity in Functions of Several Variables: Definition, properties

Unit 2: Partial Derivatives **(14 Hours)**

2.1 Definition and examples.

2.2 Higher Derivatives, Clairaut's Theorem (Statement Only)

2.3 Differentiable function - Definition, Necessary condition for differentiability (with proof), sufficient condition for differentiability (without proof), Examples, Differentials

2.4 Chain Rule, Homogeneous Functions, Euler's theorem

2.5 Extreme values of functions of two variables

2.6 Necessary conditions for extreme values

2.7 Second Derivative Test (without proof)

2.8 Lagrange's Multipliers (with one constraint)

Unit 3: Multiple Integrals **(10 Hours)**

3.1 Double Integrals in Cartesian Coordinates: Definition and computation

3.2 Change of order of integration

3.3 Double Integrals in Polar Coordinates: Converting limits to polar form

3.4 Change of Variables in Multiple Integrals: Jacobian transformation

3.5 Applications of Double Integrals: Area calculation

3.6 Triple Integrals in Cartesian Coordinates: Volume computation

3.7 Triple Integrals in Cylindrical & Spherical Coordinates: Conversion and computation

Text Book:

1. Thomas' Calculus, 13th Edition, G. B. Thomas, Revised by Maurice D. Weir, Joel Hass and Christopher Heil, Pearson Edition. Articles: 14.1 to 14.4, 14.7 & 14.8, 15.1 to 15.5, 15.7 & 15.8.

Reference Books:

1. Calculus: Early Transcendentals - James Stewart, Cengage Learning.
2. Basic Multivariable Calculus, J. E. Marsden, A. J. Tromba , A. Weinstein, Springer Verlag (Indian Edition).
3. T. M. Apostol , Calculus Vol. II (2nd Edition), John Wiley, New York, (1967).
4. Multivariable Calculus 7th Edition By James Stewart, Brooks/Cole, Cengage Learning, 2012.

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MTS-202-MJ: Laplace Transform and its Applications

Course type: Major **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Define and understand the Laplace transform, its properties, and continuity requirements.
2. Calculate the Laplace transform of various exponential order functions.
3. Find the inverse Laplace transform using techniques like partial fractions and translation theorems.
4. Solve ordinary differential equations using Laplace transforms, including initial and boundary value problems.
5. Apply Laplace transforms to solve real-world problems, including electrical circuits and periodic functions.
6. Explore advanced applications such as the Laplace transform of Gamma, Beta and Error functions.

Course Content

Unit 1: Laplace Transform **(08 Hours)**

1.1 Introduction to the Laplace Transform

1.2 Continuity Requirements

1.3 Piecewise Continuity

1.4 Exponential Order Functions

1.5 Laplace Transform of Some Exponential Order Functions

1.6 Properties of Laplace Transforms and Some Examples

Unit 2: Inverse Laplace Transform **(09 Hours)**

2.1 Inverse of the Laplace Transform

2.2 Unit Step Function

2.3 Translation Theorems

2.4 Differentiation and Integration of the Laplace Transform

2.5 Use Partial Fractions to find Inverse Laplace Transform

Unit 3: Applications of Laplace Transform **(13 Hours)**

3.1 Gamma Function and its Laplace Transform

3.2 Periodic Functions and their Laplace Transforms

3.3 Laplace Transform of Derivatives

3.4 Applications to solve Ordinary Differential Equations

i. Initial Value Problems

ii. Boundary Value Problems

iii. Systems of Differential Equations

3.5 Applications of Laplace Transform in Electrical Circuits

3.6 Convolution Theorem and its Applications

3.7 Error Function and its Laplace Transform

3.8 Beta Function and its Laplace Transform

Text Book:

1. The Laplace Transform: Theory and Applications, Joel L. Schiff, Springer New York, NY, 1999.

   Section: 1.1, 1.3, 1.4, 1.5 (Except Theorem 1.11), 1.6 (Except Theorem 1.18, Example 1.19 and Theorem 1.20), 1.7, 1.8, 1.9, 1.10, 2.1 (Except Infinite Series), 2.2, 2.3, 2.4 (Except Differential Equations with Polynomial Coefficients), 2.7 (Up to Beta Function).

Reference Books:

1. Schaum's Outline Series- Theory and Problems of Laplace Transform by Murray R. Spiegel, McGraw-HILL
2. Use of Integral Transforms by I. N. Sneddon, Tata McGraw-Hill, New York, 1972.
3. Integral Transforms and Their Applications by Debnath, Lokenath; Bhatta, Dambaru, Chapman and Hall/CRC; 3rd edition, 2014.

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MTS-203-MJP: Practicals on Calculus of Several Variables and Laplace Transform

Course type: Major **No. of Credits: 02(P)**

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[Minor Subjects]

MTS-241-MN: (A) Mathematics for Physical Science-I

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Demonstrate a clear understanding of functions of several variables and apply partial differentiation techniques to solve multivariable problems.
2. Analyse and distinguish between exact and inexact differentials and apply the chain rule and total derivatives in changing variables.
3. Perform operations with vectors, including addition, scalar multiplication, and determination of magnitudes and angles between vectors.
4. Solve geometric problems using vector methods, including finding equations and distances related to lines, planes, and spheres.
5. Apply differentiation and integration techniques to vector functions and interpret physical problems involving vector fields.
6. Evaluate and apply vector calculus operators gradient, divergence, and curl and use related vector identities in solving applied mathematical problems.

Course Content

Unit 1: Partial Differentiation **(10 Hours)**

1.1 Definition of function of several variables

1.2 Definition of the partial derivative

1.3 The total differential and total derivative

1.4 Exact and inexact differentials

1.5 The chain rule

1.6 Change of variables

Unit 2: Vector Algebra **(10 Hours)**

1.1 Vector Algebra

1.2 Scalars and vectors

1.3 Addition and subtraction of vectors

1.4 Multiplication by a scalar

1.5 Magnitude of a vector

1.6 Angle between the vectors

1.7 Multiplication of vectors

1.8 Scalar Product

1.9 Vector Product

1.10 Scalar Triple Product

1.11 Vector Triple Product

Unit 3: Vector Calculus **(10 Hours)**

3.1 Differentiation of vectors

3.2 Vector operators:

i. Gradient of a scalar field;

ii. Divergence of a vector field;

iii. Curl of a vector field

3.3 Vector operator formulae

i. Vector operators acting on sums and products

ii. Combinations of grad, div and curl

Text Book:

1. Mathematical Methods for Physics and Engineering, K. F Riley, Michael Paul Hobson, and Stephen John Bence, Cambridge University Press.

   Section 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 7.1, 7.2, 7.3, 7.5, 7.6, 10.1, 10.7, 10.8

Reference Books:

1. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley & Sons.
2. Mathematics for Chemistry, Kailas S. Ahire, Rajashri Sawant, SahityaSagar Publication 2023.

******

MTS-241-MN: (B) Mathematics for the Life Sciences-I

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the role of mathematics in biological sciences.
2. Apply Algebra and Calculus to biological systems.
3. Extend mathematical modelling techniques to complex biological systems.
4. Use discrete mathematics and computational approaches in biological research.
5. Develop basic mathematical models for biological processes.
6. Students develop skills in identifying problems, choosing appropriate mathematical tools and communicating their findings in a clear and concise manner.

Course Content

Unit 1: Functions **(10 Hours)**

1.1 Real Number System

1.2 Sets and Their Representations

1.3 Functions

1.4 Linear Functions

1.5 Linear Inequalities

1.6 Other Sample Functions

1.7 More on Functions

1.8 Limit as x tends to infinity.

Unit 2: Exponential and Logarithm Functions **(10 Hours)**

2.1 Exponential Functions

2.2 Inverse Functions and Logarithms

2.3 Log-Log and Semi-log Plots

2.4 Natural Logarithms and Exponentials

2.5 Exponential Growth and Decay

Unit 3: Vectors and Matrices **(10 Hours)**

3.1 Vectors in Two Dimensions

3.2 The Inner Product

3.3 Relative Velocities

3.4 Forces

3.5 Matrices

3.6 Applications of Matrices

Recommended Book:

1. Jagdish C. Arya and Robin W. Lardner (1979), Mathematics for the Biological Sciences, Prentice-Hall, Inc.

Reference Books:

1. Erin N. Bodine, Suzanne Lenhart and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014.
2. Edward Batschelet, Introduction to Mathematics for Life Scientists, 3rd Edition (1979), Springer.

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MTS-241-MN : (C) Mathematics for Computer Science-I

(Numerical Techniques)

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand and apply numerical methods to solve algebraic and transcendental equations, including bisection, false position, and Newton-Raphson methods, with an emphasis on error analysis and convergence.
2. Develop a strong foundation in finite difference concepts, including forward, backward, central, and other difference operators, and understand their roles in numerical approximation.
3. Apply interpolation techniques for estimating intermediate values, using Newton's Gregory formulas, Lagrange's interpolation, and divided differences.
4. Utilize numerical integration methods such as the trapezoidal rule, Simpson's one-third rule, and Simpson's three-eighth rule to approximate definite integrals.
5. Solve ordinary differential equations numerically using Euler's method, Euler's modified method, and Runge-Kutta methods, understanding their accuracy and applicability.
6. Analyze the efficiency, accuracy, and limitations of various numerical methods, enabling selection of appropriate techniques for solving real-world mathematical problems.

Course Content

Unit 1: Algebraic and Transcendental Equation **(06 Hours)**

1.1 Errors

1.2 Bisection Mehtod

1.3 False Position Method

1.4 Newton-Raphson Method

Unit 2: Calculus of Finite Differences and Interpolation **(10 Hours)**

2.1 Differences

- 2.1.1 Forward Differences
- 2.1.2 Backward Differences
- 2.1.3 Central Differences
- 2.1.4 Other Differences

2.2 Relation between Operators

2.3 Newton's Gregory Formula for Forward Interpolation

2.4 Newton's Gregory Formula for Backward Interpolation

2.5 Lagrange's Interpolation Formula

2.6 Divided Difference

2.7 Newton's Divided Difference Formula

Unit 3: Numerical Integration **(06 Hours)**

3.1 General Quadrature Formula

3.2 Trapezoidal Rule

3.3 Simpson's one-Third Rule

3.4 Simpson's Three-Eight Rule

Unit 4: Numerical Solution of Ordinary Differential Equation **(08 Hours)**

4.1 Euler's Method

4.2 Euler's Modified Method

4.3 Runge-Kutta Second Order Method

4.4 Runge-Kutta Fourth Order Method (Without Proof)

Text Book:

1. A Textbook of Computer Based Numerical and Statistical Techniques, by A. K. Jaiswal and Anju Khandelwal, New Age International Publishers.

   Chapter 1: 2.1,2.4, 2.5, 2.7

   Chapter 2: 3.1, 3.2, 3.4, 3.5,4.1, 4.2, 4.3, 5.1, 5.2, 5.4, 5.5

   Chapter 3: 6.1, 6.3, 6.4, 6.5, 6.6, 6.7

   Chapter 4: 7.1, 7.4, 7.5, 7.6

Reference Books:

1. S. S. Sastry; Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India, 1999.
2. H. C. Saxena; Finite differences and Numerical Analysis, S. Chand and Company.
3. K. E. Atkinson; An Introduction to Numerical Analysis, Wiley Publications.
4. Balguruswamy; Numerical Analysis.

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MTS-242-MN:Practical on (A) Mathematics for Physical Science-I
or
MTS-242-MN:Practical on (B) Mathematics for Life Sciences-I
or
MTS-242-MN:Practical on (C) Mathematics for Computer Science-I

Course type: Minor **No. of Credits: 02(P)**

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IKS-201-MTS: Indian Knowledge System - Mathematics

Course type: IKS **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. To introduce students to the rich mathematical heritage of ancient India.
2. To explore the contributions of Indian mathematicians and their impact on modern mathematics.
3. To understand key mathematical concepts developed in ancient Indian texts.
4. To understand the proof techniques of Indian Mathematics.
5. To know the contribution to Astronomy.
6. To correlate ancient Indian mathematics to modern mathematics.v

Course Content

Unit 1: Introduction **(03 Hours)**

1.1 Overview of the Indian Knowledge System, significance, sources

1.2 *Katapayadi* and *Bhut Sankhya* number systems

Unit 2: Contributions to Geometry **(04 Hours)**

2.1 Geometry *in Sulba Sutra*: Construction of altars, Bodhayana-Pythagorean theorem

2.2 Methods of Squaring a circle, and circling a square etc.

2.3 Approximation of square roots and irrational numbers

2.4 Cyclic quadrilaterals

Unit 3: Contributions to Arithmetic and Number Theory **(07 Hours)**

3.1 Concept of zero, its history and development

3.2 Operations with negative numbers, algebraic identities

3.3 Development of Indian numeral system and its impact

3.4 Kuttaka method for solving indeterminate equations

3.5 Chakraval Method to Solve Pell's equation

Unit 4: Algebra and Calculus **(05 Hours)**

4.1 Solutions to linear and quadratic equations

4.2 Approximations of π

4.3 Some problems from the books- *Ganitasarasangraha*, *Lilavati*, *Bijaganita*

4.4 Infinite series, early concepts of calculus.

4.5 Contribution of Kerala School of Mathematics

Unit 5: Combinatorics and Astronomy-Related Mathematics (06 Hours)

5.1 Binomial coefficients and early combinatorial methods

5.2 Pingala's algorithm for binary number system

5.3 Hemachandra-Fibonacci sequence in Indian texts (prosody, Sanskrit meter)

5.4 Sine functions and tables by Aryabhata, Bhaskar I, Madhava

5.5 Use of mathematics in Indian astronomy (planetary motion, time calculations)

Unit 6: Legacy of Indian Mathematics and Vedic Techniques (05 Hours)

6.1 Jain and Buddhist mathematicians

6.2 Proof techniques by Indian mathematicians

6.3 List of books by Indian mathematicians

6.4 List of Indian concepts of mathematics

6.5 Introduction to techniques of Vedic mathematics

6.6 Conclusion: journey of mathematics from ancient to modern times

Reference Books:

1. Dr. Balachandra Rao, Indian Mathematics and Astronomy-Some Landmarks, 6th Edition, Bhavan's Gandhi Centre for Science and Human Values, Bangalore, 2017.
2. Bhaskar Kamble, The Imperishable Seed (How Hindu Mathematics Changed the World and Why this History was Erased), Garuda Prakashan, 2022.
3. B. Datta and A. N. Singh, History of Hindu Mathematics (Volumes 1 and 2), Bharatiya Kala Prakashan.
4. T. A. Saraswati Amma, Geometry in Ancient and Medieval India, Motilal Banarasidass
5. C. N. Srinivasiengar, The History of Ancient Indian Mathematics, World Press, 1967.
6. A. K. Dutta, Series of articles on "Mathematics in India," *Bhavana* (Journal of the Indian Mathematical Society).
7. K. Ramasubramanian (Editor), Studies in Indian Mathematics and Astronomy: Selected Articles of Kripa Shankar Shukla, Hindustan Book Agency, Culture and History of Mathematics Series, Volume 2, 2010.
8. NPTEL Lectures by K. Ramasubramanian, M.D. Srinivas and M. S. Sriram. https://nptel.ac.in/courses/111/101/111101080/

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MTS-221-VSC: Foundation of Mathematics

Course type: VSC **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. To understand and compute higher-order derivatives.
2. Apply standard methods to solve integrals.
3. Solve first-order ordinary differential equations.
4. Perform operations on complex numbers.
5. To use De-Moivre's theorem to find powers and roots.
6. Represent and analyze regions in the complex plane.

Course Content

Unit 1: Successive Differentiation & Methods of Integration (14 Hours)

1.1 Calculation of the nth Derivative (some standard result).

1.2 Determination of nth derivatives of rational functions.

1.3 Integration of Algebraic Rational Functions.

1.4 Integration by Parts.

1.5 Reduction formulae for $\sin^n x$, $\cos^n x$

Unit 2: Ordinary Differential Equations (10 Hours)

2.1 Linear first order equations.

2.2 Separable equations.

2.3 Exact differential equations

2.4 Determination of Integrating factor

Unit 3: Complex Numbers (06 Hours)

3.1 Sums and Products, Basic Algebraic Properties, Moduli, Complex Conjugates, Exponential form, Products and Quotients, De-Moivre's theorem.

3.2 Roots of Complex Numbers: The nth roots of unity.

Text Books:

1. Differential Calculus by Shanti Narayan, Revised Edition.
   Units 1: Chapter 5: Sec. 5.2 to 5.3.
2. Integral Calculus by Shanti Narayan, Revised Edition.
   Units 1: Chapter 3: Sec. 3.1 to 3.7, Chapter 4: Sec. 4.1 to 4.2

3. Elementary Differential equations, William F. Trench, E-book (Free download).

   Units 2: Chapter 2: Sec. 2.1 to 2.2, 2.5 to 2.6

4. Complex Variables and Applications, James Ward Brown and Ruel V. Churchill, Mc-Graw Hill, Eighth Edition.

   Unit 3: Chapter 1: Sec 1 to 10.

Reference Books:

1. A Thomas' Calculus Maurice D. Weir, Joel Hass. Pearson.IN.
2. Differential Equations, Shepley L. Ross, Willy India Pvt.Ltd.
3. Ordinary and Partial Differential Equations, M. D. Raisingania, S. Chand and Company, 2009.
4. Calculus Volume I (Second Edition), Wiley Student Edition, T. M. Apostol, John Wiley, New Delhi.
5. Calculus Volume II (Second Edition), Wiley Student Edition, T. M. Apostol, John Wiley, New Delhi.
6. Complex Variables Theory and Application Kasana PHI.

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[Open Electives for the Students other than Faculty of Science]

OE-201-MTS: (A) Mathematics For Competitive Exams

Course type: OE **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the basic concepts of quantitative ability
2. Acquire satisfactory competency in the use of Mathematical reasoning
3. Develop theoretical, applied, and computational skills
4. Solve campus placement aptitude papers covering Quantitative Ability
5. Compete in various competitive exams like Banking, CAT, CMAT, GATE, GRE, GATE, MPSC, UPSC, etc.
6. Get adequate exposure to global and local concerns that explore many aspects of Mathematical Sciences

Course Content

Unit 1: Number System and Basic Numeracy **(12 Hours)**

1.1 Number Systems: Basic Calculation (Addition, Subtraction, Multiplication, and Division) and Simplification, BODMAS, Place Value, Face Value

1.2 Test of Divisibility, LCM and HCF

1.3 Decimals and Fractions

1.4 Simplification

1.5 Powers, Square root, and Cube root

1.6 Logarithm

1.7 Surds and Indices

1.8 Percentage

1.9 Average

1.10 Problems on Ages

1.11 Series Test: Odd Man Out and Series Completion

Unit 2: Quantitative Ability (Applied Mathematics-I) **(09 Hours)**

2.1 Ratio and Proportion

2.2 Mixtures and Allegations

2.3 Partnership

2.4 Profit and Loss

2.5 Simple Interest & Compound Interest

Unit 3: Quantitative Ability (Applied Mathematics-II) (09 Hours)

3.1 Time & Work: Problems on Unitary Methods, Problems on Alternate days and wages, Problems on Chain Rule, Problems on Pipes and Cisterns

3.2 Speed, Time, and Distance: Problems on Average and Relative Speed, Problems on Trains, boats, and streams

Text Book:

1. Quantitative Aptitude for Competitive Examinations by R.S. Aggarwal

Reference Books:

1. Fast Track Objective Arithmetic by Rajesh Verma
2. Handbook for Mathematics by Arihant Experts
3. Objective Arithmetic (SSC & Railway Exam Special) by R.S Aggarwal
4. Teach Yourself Quantitative Aptitude by Arun Sharma
5. The Pearson Guide to Quantitative Aptitude for Competitive Examination by Dinesh Khattar
6. Quantitative Aptitude for all Competitive Exams by Abhijit Gupta
7. NCERT Math Books of 10th,11th, and 12th

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OE-201-MTS: (B) Mathematics for Social Science-I

Course type: OE **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Explain the role and scope of statistics in diverse fields such as social sciences, management, insurance, and information technology etc.
2. Understand various sampling methods, and data classifications
3. Construct and interpret frequency distributions and apply appropriate methods for data classification
4. Represent data using appropriate diagram for effective communication of statistical findings
5. Calculate and describe data through measures of central tendency
6. To develop student's understanding of statistical averages and their applications in data analysis

Course Content

Unit 1: Statistics, Population and Sample **(10 Hours)**

1.1 Meaning of Statistics as a Science. Importance of Statistics. Scope of Statistics: In the field of Social Sciences, Psychology, Industry, Economics, Management sciences, Agriculture, Insurance, Information technology, Education etc.

1.2 Notion of a statistical population: Finite population, infinite population, homogeneous population and heterogeneous population. Notion of a sample and a random sample

1.3 Methods of sampling (Description only): Simple random sampling with and without replacement (SRSWR and SRSWOR) stratified random sampling, systematic sampling, illustrations for each sampling method.

Unit 2: Types of characteristics **(10 Hours)**

2.1 Attributes: Nominal scale, ordinal scale,

2.2 Variables: Interval scale, ratio scale, discrete and continuous variables, difference between linear scale and circular scale

2.3 Types of data: (a) Primary data, Secondary data (b) Cross-sectional data, time series data, directional data.

2.4 Classification: Raw data and its classification, inclusive and exclusive methods of classification, open end classes, ungrouped frequency distribution, Sturges' rule, grouped frequency distribution, cumulative frequency distribution and relative frequency distribution.

2.5 Representation of data: Bar Diagrams, Pie-Diagram, Histogram, frequency polygon, frequency curve and Ogive curves

Unit 3: Statistical Averages **(10 Hours)**

3.1 Concept of central tendency of statistical data, Statistical averages, characteristics of a good statistical average.

3.2 Arithmetic Mean (A.M.): Definition, effect of change of origin and scale, combined mean of a number of groups, merits and demerits, trimmed arithmetic mean.

3.3 Mode and Median: Definition, formulae (for ungrouped and grouped data), Empirical relation between mean, median and mode (without proof).

3.4 Partition Values: Quartiles, Deciles and Percentiles (for ungrouped and grouped data), Box plot. Situations where one kind of average is preferable to others.

3.5 Case study

Recommended Books

1. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, Third Edition, Sultan Chand and Sons Publishers, New Delhi.

2. Agarwal, B. L. (2003). Programmed Statistics, Second Edition, New Age International Publishers, New Delhi.

3. Ghosh, J. K. and Mitra, S. K., Parthsarthi, K. R. (1993). Glimpses of India's Statistics Heritage, Wiley publishing Co.

4. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition, The World Press Pvt. Ltd., Calcutta.

5. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, New Delhi.

6. Neil A. Weiss, (2016). Introductory Statistics, Tenth Edition, Pearson.

7. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi.

8. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentce Hall of India, New Delhi.

9. Snedecor G. W. and Cochran W. G.(1989). Statistical Methods, Eighth Ed. East- West Press.

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OE-201-MTS: (C) Commercial Mathematics I

Course type: OE **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Define and recall fundamental concepts of quadratic equations and progressions
2. Explain the relationship between roots and coefficients of a quadratic equation
3. Apply arithmetic and geometric progressions to real-world problems
4. Solve basic counting problems using fundamental principles of counting
5. Apply fundamental principles of probability to solve problems involving uncertainty, including the use of probability rules, conditional probability, and expected value, in business and real-life contexts
6. Create computational skills essential to compete in various competitive exams like CA, CAT, CMAT, GATE, GRE, GATE, UPSC, GPSC etc.

Course Content

Unit 1: Quadratic Equations and Progressions **(10 Hours)**

1.1 Quadratic equations and solutions

1.2 Polynomials and their factorizations

1.3 Number series and Progressions: Problems on Arithmetic progression, Geometric Progression and Harmonic Progressions

1.4 Problems on Number and letter series

Unit 2: Counting Principles **(08 Hours)**

2.1 Permutations: Linear and Circular, Permutations with or without repetitions

2.2 Combinations

2.3 Fundamental principles of counting: Problems on Addition and multiplication rule

2.4 Elementary problems on permutations and Combinations

2.6 Binomial theorem

Unit 3: Probability **(12 Hours)**

3.1 Introduction to Probability

3.2 Meaning of probability

3.3 Basic concepts: random experiment, sample space, event, types of events (simple, compound, mutually exclusive, exhaustive, independent, dependent)

3.4 Classical and empirical definitions of probability

3.5 Addition theorem (for mutually exclusive and non-mutually exclusive events)

3.6 Multiplication theorem (for independent and dependent events)

3.7 Complementary events

3.8 Conditional Probability

3.9 Definition and application

3.10 Use of multiplication rule in conditional probability

3.11 Bayes' Theorem: Statement and application of Bayes' theorem in solving problems

Reference Books:

1. Discrete Mathematics and its Applications, Kenneth H. Rosen, MCgraw Publications
2. Finite Mathematics for Business, Economics, Life sciences and Social Sciences, Barnett, Ziegler, Byleen, Stocker, Pearson, 14th Edition
3. Higher Algebra, Hall & Knight, Arihant Publications (Indian Edition)
4. Analytical and Logical reasoning By Sijwali B S
5. Business Mathematics by VK Kapoor,
6. CA Foundation Business Mathematics, Logical Reasoning & Statistics by P. N. Arora, S Arora, sultan Chand Publications
7. Statistics for CA Foundation by R. D Sharma

Semester -IV

MTS-251-MJ: Linear Algebra

Course type: Major **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand and analyze vector spaces, subspaces, and basic concepts.
2. Compute null space, column space, and verify orthogonality of vectors.
3. Define linear transformations and apply the Rank-Nullity Theorem.
4. Find eigenvalues, eigenvectors, and diagonalize matrices using Cayley-Hamilton Theorem.
5. Apply eigenvalue methods to Principal Component Analysis (PCA).
6. Use inner product space concepts and perform Gram-Schmidt orthonormalization.

Course Content

Unit 1: Vector Spaces **(10 Hours)**

1.1 Vector Spaces and Subspaces

1.2 Linear Combination, Dependence, Independence, Basis, and Dimension

1.3 Null Space and Column spaces

1.4 Orthogonally of Vectors and Subspaces

Unit 2: Linear Transformations **(06 Hours)**

2.1 Linear transformation: Definition, Properties and Examples

2.2 Matrix of a Linear transformation with respect to standard basis

2.3 Kernel and Range of Linear Transformation

2.4 Rank-Nullity Theorem (Statement and Problems only)

Unit 3: Eigen Values and Eigen Vectors **(08 Hours)**

3.1 Introduction to Eigenvalues: $Ax = \lambda x$

3.2 Eigen Vectors

3.3 Characteristic Equations, Caley-Hamilton Theorem (Statement and Problems only)

Unit 4: Inner Product Spaces **(06 Hours)**

4.1 Inner Product Spaces: Definition, Properties and Examples

4.2 Orthogonal and Orthonormal vectors

4.3 Norm of a vector

4.4 Gram - Schmidt Process of Orthonormalization

Recommended Book:

1. Gilbert Strang, Introduction to Linear Algebra, 6th Edition, Wellesley-Cambridge Press.

Reference Books:

1. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning Pvt. Ltd., 2000.
2. David C. Lay, Steven R. Lay, and Judi J. McDonald, Linear Algebra and Its Applications, 5th Ed. Pearson Publication, 2015.
3. Seymour Lipschutz, Schaum's Outline of Linear Algebra, 5th Ed., McGraw Hill, 2012.

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MTS- 252-MJ: Vector Calculus

Course type: Major **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Vector calculus motivates the study of vector differentiation and integration in two and three dimensional spaces.
2. This course enables students to understand vector differentiation and its applications in various fields
3. Students are well equipped to apply concepts like vector fields, derivatives, integrals, and theorems likes Greens theorems stokes and divergence theorems
4. The students receive knowledge of concepts in directional derivatives, gradients, multiple integrals, line and surface integrals, vector fields, divergence, curls
5. Students will able to learn the concepts of vector fields, Gradients fields
6. Students are aware about the gradient, divergence, curl operator and their applications.

Course Content

Unit 1: Vector Valued Functions **(08 Hours)**

1.1 Curves in Space, Limits and Continuity, Derivatives and Motion, Differentiation Rules for Vector Function, Vector Functions of Constant Length.

1.2 Integrals of Vector Functions.

1.3 Arc Length along a Space Curve, Speed on a Smooth Curve, Unit Tangent Vector.

1.4 Curvature of a Plane Curve, Circle of Curvature for Plane Curves, Curvature and Normal Vectors for a Space Curve.

Unit 2: Integrals **(14 Hours)**

2.1 Line Integral of Scalar Functions, Additivity, Line integral in the Plane.

2.2 Vector Fields, Gradient of a scalar field, Line Integral of Vector Fields, Line Integrals.

2.3 Work done by a Force over a Curve in Space, Flow Integrals and Circulation for Velocity Fields, Flux across the Simple Closed Plane Curve.

2.4 Path Independence, Conservative and Potential Functions.

2.5 Divergence, Two forms for Green's Theorem, Green's Theorem in the Plane (1 - form only)

Unit 3: Surface Integrals **(08 Hours)**

3.1 Parameterizations of Surfaces, Implicit surfaces, surface area, surface integrals.

3.2 The Curl of Vector Field, Conservative Fields and Stokes' Theorem (without proof).

3.3 Divergence in three Dimensions, Divergence Theorem (without proof).

Text Book:

1. Thomas' Calculus (14th Edition) by Hass, Heil, Weir, Pearson.

   Unit 1: Chapter 13: Sec- 13.1, 13.2, 13.3, 13.4

   Unit 2: Chapter 16: Sec-16.1, 16.2, 16.3, 16.4

   Unit 3: Chapter 16: Sec- 16.5, 16.6 , 16.7, 16.8

Reference Book:

1. Basic Multivariable Calculus by J. E. Mardson, A. J. Tromba, A. Weinstein, Springer Verlag (Indian Edition)
2. Advanced Calculus by M.R. Spiegel, Schaum Series.
3. Advanced Calculus (IInd Edition) by D.V. Widder, Prentice Hall of India, New Delhi (1944).
4. Advanced Calculus by John M. H. Olmsted, Eurasia Publishing House, New Delhi (1970)
5. Calculus Vol. II (2nd Edition) by T. M. Apostol, John Wiley, New York (1967).

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MTS-253-MJP: Practical on Linear Algebra and Vector Calculus

Course type: Major **No. of Credits: 02(P)**

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[Skill Enhancement Course]

SEC-251-MTS: LaTex

Course type: SEC **No. of Credits: 02(P)**

Course Outcomes: Students will able to

1. Students will be able to create well-structured, professional documents using LaTeX.
2. Learners will gain the ability to typeset mathematical equations, scientific content, and complex layouts effectively.
3. Students will demonstrate proficiency in incorporating graphics, tables, and multimedia elements into their documents.
4. Students will be able to troubleshoot common issues and extend LaTeX capabilities using custom packages and configurations.
5. Learners will be prepared to use LaTeX for academic writing, publishing, and professional documentation tasks.
6. Students will be able to create well-structured, professional documents using LaTeX

Course Content

Unit 1: LaTeX Basics **(04 Hours)**

1.1 What is Latex?

1.2 How LaTeX works

1.3 The LaTeX input files

1.4 Installation of MikTex

1.5 Introduction of Console

1.6 Overleaf-online LaTeX Editor

Unit 2: Creating LaTex Document **(06 Hours)**

2.1 Document Classes

2.2 Packages

2.3 Making a Title page

2.4 Making a Table of contents

2.5 Page styles

2.6 Margins

Unit 3: Within the Text **(06 Hours)**

3.1 Changing Type Style and Size

3.2 Spaces

3.3 Drawing Rules

3.4 Centering

3.5 Making Lists

Unit 4: Tabular Environment in Latex **(08 Hours)**

4.1 Changing Type Style and Size

4.2 Spaces

4.3 Drawing Rules

4.4 Centering

4.5 Multicolumn and multirow

Unit 5: Typesetting Mathematics **(20 Hours)**

5.1 In-line Math

5.2 Display Math

5.3 AMS packages

5.4 Simple Mathematical formulas

5.5 Equation Environment (numbered and unnumbered)

5.6 Creating Matrices

5.7 Building Mathematical Expressions

Unit 6: Including Graphics **(04 Hours)**

6.1 Graphics environment

6.2 Importing Graphic into LaTeX document

6.3 Captions and Sub-captions

6.4 Images through TexCAD

6.5 Tikz LaTex

Unit 7: Beamer presentation **(12 Hours)**

7.1 Documentclass

7.2 Beamerthemes

7.3 Beamercolors

7.4 Creating frames

7.5 Animations

7.6 LaTeX for quizes

Reference Books:

1. More Math into Latex, by George Gratzer, 4th Edition, Springer-Verlag, New Yark.
2. A Guide to LaTeX by Helmut Kopka and Patrick W. Daly, 4th Edition, Addison-Wesley.

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[Minor Subjects]

MTS-291-MN: (A) Mathematics for Physical Science-II

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand and classify different types of first-order differential equations and solve them using appropriate analytical techniques such as separable, linear, exact, and homogeneous methods.
2. Apply integrating factors and solve real-world problems modeled by first-order differential equations, including applications in electrical circuits and population dynamics.
3. Analyze and solve second-order linear differential equations with constant coefficients, and determine their general solutions.
4. Interpret and model physical systems such as undamped and damped harmonic oscillators using second-order differential equations.
5. Solve initial value problems numerically using Euler's method, Modified Euler's method, and Runge-Kutta methods.
6. Demonstrate the ability to choose and apply suitable analytical or numerical methods for solving differential equations in applied contexts.

Course Content

Unit 1: Differential Equations **(15 Hours)**

1.1 Introduction

1.2 Nature of Solutions

1.3 Separable Equations

1.4 First Order Linear Equations

1.5 Exact Equations

1.6 Homogeneous Equations

1.7 Integrating Factors

1.8 Real life applications of First Order Differential Equations

i. Bacterial growth

ii. Half-Life decay of radioactive materials

iii. Age of fossil

iv. Newton's law of cooling

v. Population dynamics (Logistic Model)

Unit 2: Second Order Differential Equations **(08 Hours)**

2.1 Introduction

2.2 Second-order linear equations

2.3 General solutions to homogeneous differential equations with constant coefficients

2.4 Real life applications of Second Order Differential Equations:-

i. Vibrations and oscillations

ii. Undamped Simple Harmonic Motion

iii. Damped Vibrations (without external force).

Unit 3: Numerical Solutions to Differential Equations **(07 Hours)**

3.1 Introduction to the Initial value problems

3.2 Euler's method

3.3 Improved / Modified Euler's method

3.4 Second Order Runge-Kutta Method

3.5 Fourth Order Runge-Kutta Method (Without Derivation)

Recommended Book:

1. Differential Equations: Theory, Technique, and Practice, George F. Simmons and Steven G. Krantz, Tata McGraw-Hill Edition.

   Section: 1.1, 1.2, 1.3, 1.4, 1.5, 1.7, 1.8, 2.1, 2.5.1, 2.5.2

Reference Books:

1. First Course in Differential Equations with Modeling Applications, Ninth Edition, Dennis G. Zill, CengagePublications.Section: 3.1

2. Differential Equations Theory, Technique, and Practice with Boundary Value Problems, Steven G. Krantz, CRC Press. Section: 4.1, 4.2, 4.4, 4.5

3. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI publications.

4. Mathematics for Chemistry, Kailas S. Ahire, Rajashri Sawant, Sahitya Sagar Publication 2023.

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MTS-291-MN: (B) Mathematics for the Life Sciences-II

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the role of mathematics in biological sciences.
2. Apply Algebra and Calculus to biological systems.
3. Extend mathematical modelling techniques to complex biological systems.
4. Use discrete mathematics and computational approaches in biological research.
5. Develop basic mathematical models for biological processes.
6. Students develop skills in identifying problems, choosing appropriate mathematical tools and communicating their findings in a clear and concise manner.

Course Content

Unit 1: The Derivative **(10 Hours)**

1.1 Increments and Rates

1.2 Limits

1.3 More on Limits

1.4 Continuous Functions

1.5 The Derivative

1.6 Derivatives of Power Functions

1.7 Derivatives of Products and Quotients

1.8 Derivatives of Composite Functions

1.9 Higher Derivatives

Unit 2: Applications of Derivative **(10 Hours)**

2.1 Analysis of Curves

2.2 Maxima and Minima

2.3 Applications of Maxima and Minima

2.4 Newton's Method

2.5 The Differentials dx and dy.

2.6 Implicit Differentiation

2.7 Parametric Equations

Unit 3: Integration **(10 Hours)**

3.1 Antiderivatives

3.2 Method of Substitution

3.3 Tables of Integrals

3.4 Method of Partial Fractions

3.5 Trigonometric Substitutions

3.6 Integration by Parts

Recommended Book:

1. Jagdish C. Arya and Robin W. Lardner (1979), Mathematics for the Biological Sciences, Prentice-Hall, Inc.

Reference Book:

1. Erin N. Bodine, Suzanne Lenhart and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014.

2. Edward Batschelet, Introduction to Mathematics for Life Scientists, 3rd Edition (1979), Springer.

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MTS-291- MN: (C) Mathematics for Computer Science-II (Computational Geometry)

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the fundamental concepts and mathematical representations of two-dimensional transformations, including translation, rotation, scaling, reflection, and shearing.

2. Apply transformation matrices to perform and combine 2D geometric transformations on points, lines, and simple shapes using homogeneous coordinates.

3. Analyze three-dimensional transformations such as scaling, shearing, reflection, and rotation about coordinate axes and planes, and their application in object manipulation.

4. Construct and interpret different types of projections, including orthographic, axonometric, and oblique projections, for visualizing 3D objects on 2D planes.

5. Develop parametric representations of common plane curves such as circles and hyperbolas, and generate these curves through mathematical methods.

6. Demonstrate the ability to integrate multiple transformation techniques and projections to solve basic computer graphics problems involving geometric modeling.

Course Content

Unit 1: Two dimensional transformations **(10 Hours)**

1.1 Introduction

1.2 Representation of points

1.3 Transformations and matrices.

1.4 Transformation of points.

1.5 Transformation of straight lines

1.6 Midpoint Transformation

1.7 Transformation of parallel lines

1.8 Transformation of intersecting lines

1.5 Transformation: rotations, reflections, scaling, shearing

1.6 Combined transformations

1.7 Transformation of a unit square.

1.8 Solid body transformations

1.9 Translations and homogeneous coordinates

Unit 2: Three dimensional transformations **(07 Hours)**

2.1 Introduction

2.2 Three dimensional Scaling, shearing, rotation, reflection, translation

2.3 Multiple transformations

2.4 Rotation about an axis parallel to coordinate axes,

2.5 Reflection through coordinate planes

Unit 3: Projection **(07 Hours)**

3.1 Orthographic projections.

3.2 Axonometric projections.

3.3 Oblique projections.

3.4 Application of projection

Unit 4: Plane Curves **(06 Hours)**

4.1 Introduction

4.2 Curve representation

4.3 Parametric curves

4.4 Parametric representation of a circle and generation of circle

4.5 Parametric representation of an hyperbola and generation of hyperbola

Text Book:

1. D. F. Rogers, J. A. Adams, Mathematical elements for Computer graphics, Mc Graw Hill Intnl Edition.

   Chapter 1: 2-1 to 2.14

   Chapter 2: 3.1 to 3.7,

   Chapter 3: 3.12 to 3.12

   Chapter 4: 4.1, 4.2, 4.6

Reference books:

1. Schaum Series, Computer Graphics. .
2. M. E. Mortenson, Computer Graphics Handbook, Industrial Pres Inc

MTS-292-MN:Practical on (A) Mathematics for Physical Science-II
or
MTS-292-MN:Practical on (B) Mathematics for Life Sciences-II
or
MTS-292-MN:Practical on (C) Mathematics for Computer Science-II

Course type: Minor **No. of Credits: 02(P)**

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[Open Electives for the Students other than Faculty of Science]

OE-251-MTS: (A) Mathematics for Competitive Exams-II

Course type: OE **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the basic concepts of quantitative ability.
2. Acquire satisfactory competency in use of Mathematical reasoning.
3. Develops theoretical, applied and computational skills.
4. Develop strong analytical and mathematical skill for the competitive exams.
5. Solve campus placements aptitude papers covering Quantitative Ability.
6. Compete in various competitive exams like Banking, CAT, CMAT, GATE, GRE, GATE, MPSC, UPSC etc.

Course Content

Unit 1: Calendar and Clocks **(05 Hours)**

1.1 Calendar Problems

1.2 Clock Problems

Unit 2: Geometry and Mensuration **(10 Hours)**

2.1 Lines and Angles

2.2 Triangles

2.3 Quadrilaterals

2.4 Circles

2.5 Polygons

2.6 Areas and Volumes

Unit 3: Permutation and Combination **(08 Hours)**

3.1 Problems on linear arrangement

3.2 Problems on circular arrangement

3.3 Problems when repetitions are allowed

3.4 Problems on selections

Unit 4: Probability **(07 Hours)**

4.1 Problems on coins, dice, leap year and non-leap year

4.2 Problems on deck of cards, balls

4.3 Problems on addition and multiplication theorems

Recommended Books:

1. Fast Track Objective Arithmetic by Rajesh Verma
2. Handbook for Mathematics by Arihant Experts.
3. Quantitative Aptitude for Competitive Examinations by R S Aggarwal .
4. Objective Arithmetic (SSC and Railway Exam Special) by R.S Aggarwal.
5. Teach Yourself Quantitative Aptitude by Arun Sharma.
6. The Pearson Guide To Quantitative Aptitude For Competitive Examination by Dinesh Khattar.
7. Quantitative Aptitude for all Competitive Exam by Abhijit Gupta.
8. NCERT Math Books for 10th,11th and 12th.

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OE-251-MTS: (B) Mathematics for Social Science-II

Course type: OE **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Explain the various measures of dispersion and their applications in social sciences.
2. Assess the symmetry of frequency distributions using skewness measures such as Bowley's and Karl Pearson's coefficients.
3. Evaluate frequency distribution's peakedness and shape using kurtosis measures.
4. Apply statistical techniques learned to real-world problems in social sciences and related fields.
5. Calculate and describe data through measures of central dispersion.
6. To enhance applications of statistical techniques in social sciences

Course Content

Unit 1: Measures of Dispersion **(15 Hours)**

1.1 Concept of dispersion, characteristics of good measure of dispersion.

1.2 Range, Semi-interquartile range (Quartile deviation): Definition. Mean deviation: Definition, statement of minimal property (without proof). Mean squared deviation: Definition, minimal property of mean squared deviation (without proof).

1.3 Variance and standard deviation: Definition, effect of change of origin and scale (without proof).

1.4 Measures of dispersion for comparison: coefficient of range, coefficient of quartile deviation and coefficient of mean deviation, coefficient of variation (C.V.)

Unit 2: Moments, Skewness and Kurtosis **(15 Hours)**

2.1 Moments: Raw moments and Central moments for ungrouped and grouped data, Effect of change of origin and scale on central moments (without proof). Relations between central moments and raw moments, upto 4-th order (only formulae)

2.2 Skewness: Concept of skewness of frequency distribution, positive skewness, negative skewness, symmetric frequency distribution.

2.3 Bowley's coefficient of skewness: Bowley's coefficient of skewness lies between -1 and 1(without proof), Karl Pearson's coefficient of skewness.

2.4 Kurtosis: Concepts of kurtosis, leptokurtic, mesokurtic and platykurtic frequency distributions. Measures of kurtosis based on moments. Comment on type of skewness.

Recommended Books:

1. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, Third Edition, Sultan Chand and Sons Publishers, New Delhi.

2. Agarwal, B. L. (2003). Programmed Statistics, Second Edition, New Age International Publishers, New Delhi.

3. Ghosh, J. K. and Mitra, S. K., Parthsarthi, K. R. (1993). Glimpses of I ndia's Statistics Heritage, Wiley publishing Co.

4. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition, The World Press Pvt. Ltd., Calcutta.

5. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, New Delhi.

6. Neil A. Weiss, (2016). Introductory Statistics, Tenth Edition, Pearson.

7. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, New Delhi.

8. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentce Hall of India, New Delhi.

OE-251-MTS: (C) Commercial Mathematics II

Course type: OE **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Recall and explain fundamental financial mathematics concepts
2. Compute interest, accumulated and discounted values in various financial scenarios
3. Analyze and interpret financial outcomes using the equation of value
4. Evaluate different financial instruments and repayment methods
5. Understand the basic concepts related the finance and become financially literate.
6. Design amortization schedules and annuity plans for practical scenarios

Course Contents

Unit 1: : Simple Interest and Compound Interest (15 Hours)

1.1 Simple Interest

- The time between dates
- Equation of value
- Partial payments
- Simple discount

1.2 Compound interest

- Accumulated value
- Equivalent rates
- Discounted value
- Accumulated and discounted values for fractional periods
- Finding the rate
- Finding the time
- Equation of value
- Compound discount a ta discount rate

Unit 2: : Annuities and Loans (15 Hours)

2.1 Annuities

Definition and notation

- Accumulated value of an ordinary simple annuity
- Discounted value of an ordinary simple annuity
- Other simple annuities
- Finding the term of an annuity
- Finding the interest rate
- General annuities
- Perpetuities
- Annuities whose payments vary

2.2 Loans and sinking funds

- EMI using flat interest rate method
- EMI using floating interest rate methods
- Amortization of a debt
- Outstanding principal
- Mortgages
- Refinancing a loan
- Sinking funds
- Comparison of amortizations and sinking fund methods

Reference Books:

1. Mathematics of Finance, Petr Zima, Robert L. Brown, Schaum's Outline Series, McGraw Hill (2nd edition)
2. Math in Society, David Lippman, Open Education Resource (OER) Libre Texts Project
3. Financial Mathematics, A. Lenin Jothi, Himalaya Publishing House.

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MTS-271-VSC: R Programming

Course type: VSC **No. of Credits: 02(P)**

Course Outcomes: Students will able to

1. Demonstrate how to install R software.
2. Explain the use of data structures and conduct arithmetic operations.
3. Using R, solve complicated differentiation and integration problems.
4. Perform different operations on matrices and test their characteristics.
5. Visualize the data using a diagrammatic form.
6. Import datasets in R and export outputs from R.

Course Content

Unit 1: Introduction to R (20 Hours)

1.1 Getting Started with R Programming

R is a free, Open Source Programming Language, so students can download from R Programming project Website and install on their own machine (Linux, Windows or MacOS). They do have RStudio, which is an integrated development environment (IDE) that provides a user-friendly interface. The section covers the following topics.

- Installation of R
- Use of R console
- R script/ editor file, R Prompt, Menu Ribbon, Saving R editor/script file
- Clearing R console,
- Comments (single line, multiple line)
- Packages,
- Taking help in R
- Closing R session.

1.2 R Operators:

Assignment Operators: =, $<-$, $->$, $<<-$, $->>$, assign()

Arithmetic Operators: addition (+), subtraction (-), multiplication (*), division(/), exponent (ˆ or **), remainder operator (%%), Integer division (%/%)

Comparison Operators: equal to (==), less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), not equal to (! =)

Logical Operators: element wise logical AND (&), logical AND (&&), element wise logical OR (|), logical OR (| |), logical NOT (!), xor(), isTRUE(), isFALSE().

1.3 Data Structures and R Objects: Constants, Variables, Vectors, Matrices, Data Frame, Factors, Lists, Arrays

Vectors: creating vectors using scan(), combine (c()), seq(), sequence operator (:), rep(). numeric vector, character vector, factors, converting numeric vectors into character vectors, converting character vectors into factors, checking variable types using class(), typeof(), is.numeric(), is.character(), is.factor(), arithmetic operations on vectors, printing vectors using print(), cat() functions.

Matrices: creating matrix using matrix(), creating identity matrix using diag(), creating null matrix using diag(), converting matrices into data frames using as.data.frame(), checking the dimensions of the matrix using dim(), nrow(), ncol(), extracting rows, columns or elements of matrix.

Data frames: creating dataframes using data.frame(), converting data frames into matrices using as.matrix(), view data frames in a new window using View(), extracting variables from a dataframe using $ and [ ], subsetting of data frames using subset() and [ ].

Lists: Creating lists, storing and extracting elements of lists, applying functions on list using lapply().

1.4 R as a calculator:

BODMAS rule. Basic Mathematical functions: sqrt(), exp(), abs(), round() ceiling(), floor(), log(), log10(), sum(), prod(), cumsum(), cumprod(), min(), max(), diff(), sign(), pi, sort(), order(), etc.

Complex Numbers: complex(), is.complex(), as.complex(), Re(), Im(), Mod(), Arg(), Conj() etc.

Special Functions: beta(), gamma(), choose() and factorial() in base R, combn() and permn() available in R package combinat.

Trigonometric functions: sin(), cos(), tan() etc.

Set operations: union(), intersect(), setdiff(), setequal(), is.element(), %in%, all(), cross product of two sets.

Unit 2: Matrix Operations in R **(15 Hours)**

2.1 Matrix Manipulation: dim(), colnames(), rownames(), cbind() , rbind(), colSums(), rowSums(), colMeans(), rowMeans(), apply().

2.2 Arithmetic Operations on matrix: Addition, subtraction, multiplication of matrices, row sums and column sums of matrix, power of a matrix.

2.3 Matrix Product: matrix multiplication (%*%), crossprod(), Outer product (%o%).

2.4 Rank of matrix using rankMatrix(), transpose of a matrix using t(), Finding determinant of matrix using det(), finding inverse of matrix using solve(), trace of a matrix.

2.5 Verifying properties of trace of matrix and transpose of matrix, solving system of linear equations using solve().

Unit 3: Differentiation and Integration in R **(10 Hours)**

3.1 Defining mathematical functions in R, expression(), D(), deriv, eval(), numericDeriv(),

3.2 integrate(), uniroot(), ysym(), Sym(), lim(), Limit().

3.3 Examples on differentiation and integration.

3.4 Solving polynomial equations using polyroot()

Unit 4: Data Visualization in R **(15 Hours)**

4.1 Importing data available in .csv and .txt files into R,

4.2 Exporting outputs and base R datasets in .csv and .txt files from R.

4.3 Pie diagram for raw data and frequency table, Venn diagrams.

4.4 Barplot: simple barplot, subdivided barplot, multiple barplot.

4.5 line plot for time series data, spike plot for discrete frequency distribution,

4.6 Histogram for raw data and continuous frequency distribution with equal and unequal class width.

4.7 Exporting plots and diagrams from R in MS-word.

Recommended Books:

1. Long, J.D. Teetor P.(2019). R Cookbook (2nd Edition). O'Reilly Media, Inc.
2. Pfaff, T. (2019). R For College Mathematics and Statistics (first edition.). Chapman and Hall/CRC., New York.
3. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R (second edition). Narosa Publishing House, New Delhi.
4. Tilman M. Davies (2015). The Book of R: A First Course in Programming and Statistics (first edition). No Starch Press, USA.

List of Practicals

1. Using R as a calculator (Unit I)
2. Mathematical Computations using R functions (Unit I)
3. Vectors and arithmetic operations on vectors (Unit I)
4. Dealing with data frames and lists in R (Unit I)
5. Set Operations (Unit I)
6. Creating matrices and performing arithmetic operations (Unit II)
7. Computation of determinant, trace, inverse, power of matrix and verifying matrix properties (Unit II)
8. Solving system of linear equations (Unit II)
9. Solving differentiation problems using R (Unit III)
10. Solving integration problems using R (Unit III)
11. Visualization of the Data in R (Unit IV)
12. Graphical representation of the Data In R (Unit IV)

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Savitribai Phule Pune University

(Formerly University of Pune)

Four Year Graduate Degree Programme in Mathematics

(Faculty of Science & Technology)

New

Syllabi for

T. Y. B. A. / B. Sc. - Mathematics

(For Colleges Affiliated to Savitribai Phule Pune University, Pune)

(As per National Education Policy- 2020)

To be implemented from the Academic Year 2026-2027

Syllabus for T. Y. B.Sc. Mathematics as Per NEP-2020

Semester - V

MTS-301-MJ : Metric Spaces

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and examples of metric spaces, convergence, continuity, and compactness.
2. Understand: Explain concepts of open and closed sets, limit points, Cauchy sequences, and topological properties.
3. Apply: Apply definitions of continuity and compactness to determine properties of functions and sets.
4. Analyze: Analyze convergence of sequences, completeness of metric spaces, and uniform continuity of functions.
5. Evaluate: Evaluate properties of compact spaces, including continuous functions and equivalent definitions.
6. Create: Apply metric space concepts to solve problems in analysis, topology, and other areas of mathematics.

Course Contents

Unit 1 : Basic Notions **(06 Hours)**

1.1 Definition and examples of metric spaces

1.2 Open balls and open sets

1.3 Closed ball and closed sets

Unit 2 : Convergence **(06 Hours)**

2.1 Convergent sequences

2.2 Limit points and cluster points

2.3 Cauchy sequences and completeness

2.4 Bounded sets

2.5 Dense sets

2.6 Boundary of a set

Unit 3 : Continuity **(08 Hours)**

3.1 Continuous functions

3.2 Equivalent definitions of continuity

3.3 Topological properties

3.4 Uniform continuity

3.5 Open and closed maps

Unit 4 : Compactness **(06 Hours)**

4.1 Compact spaces and their properties

4.2 Continuous Function on Compact Spaces

Unit 5 : Connectedness **(04 Hours)**

5.1 Connected Spaces

5.2 Path Connected Spaces

Text Book:

1. Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House ,2011.
   Unit 1: Chapter 1−Sections 1.1
   Sections 1.2
   Unit 2: Chapter 2 −Sections 2.1
   Sections 2.2
   Sections 2.3
   Sections 2.4
   Sections 2.5
   Sections 2.7
   Unit 3: Chapter 3 −Sections 3.1
   Sections 3.2
   Sections 3.3
   Sections 3.4
   Sections 3.5
   Unit 4: Chapter 4−Sections 4.1
   Sections 4.2

Reference Books:

1. Metric Spaces, Q.H. Ansari: Narosa Publishing House, New Delhi
2. Metric Spaces, E. T. Copson, University Press, Cambridge, 2nd edition
3. Metric Spaces, Satish Shirali, H. Vasudeva, Springer.
4. Real Analysis by Charles Pugh Chapman,2nd edition

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MTS-302-MJ : Real Analysis– I

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall and recognize key concepts in set theory, sequences, and series of real numbers.
2. Understand: Explain the definitions and properties of convergent and divergent sequences, and apply them to determine convergence.
3. Apply: Use operations on convergent sequences to solve problems and analyze limit superior and limit inferior.
4. Analyze: Investigate convergence and divergence of series, and apply tests for absolute convergence.
5. Evaluate: Determine conditional convergence and absolute convergence of series, and justify conclusions.
6. Create: Apply knowledge of sequences and series to analyze and solve problems in real analysis.

Course Contents

Unit 1 : Set Theory and Functions **(04 Hours)**

1.1 Cantor Sets

1.2 Relations and Functions

1.3 Countable and Uncountable Sets

Unit 2 : Sequences of Real Numbers **(06 Hours)**

2.1 Definition of a sequence and subsequence

2.2 Limit of a sequence

2.3 Convergent sequences

2.4 Divergent sequences

2.5 Bounded sequences

2.6 Monotone sequences

Unit 3 : Operations on Convergent Sequences **(08 Hours)**

3.1 Operations on convergent sequences

3.2 Operations on divergent sequences

3.3 Limit superior and limit inferior

3.4 Cauchy sequences

Unit 4 : Series of Real Numbers **(06 Hours)**

4.1 Convergence and divergence of series

4.2 Series with non-negative terms

4.3 Alternating series

4.4 Conditional convergence and absolute convergence

Unit 5 : Tests for Series convergence **(06 Hours)**

5.1 Tests for absolute convergence

5.2 Series whose terms form a non−increasing sequence

5.3 The class l^2

Recommended Books:

1. Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley & Sons
   Unit 1: Chapter 1, Sections 1.1−1.6
   Unit 2: Chapter 2, Sections 2.1−2.6
   Unit 3: Chapter 2, Sections 2.7−2.10
   Unit 4: Chapter 3, Sections 3.1−3.4
   Unit 5: Chapter 5, Section 3.6−3.7,3.10

Reference Books:

1. Real Analysis, N. L. Carothers, Cambridge University Press
2. Introduction to Real Analysis, Third Edition, Robert G. Bartle and Donald R. Sherbert, John Wiley & Sons
3. Real Analysis and Foundations, Second Edition, Steven G. Krantz, Chapman & Hall/CRC

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MTS-303 MJP : Practical on Metric Spaces and Real Analysis-I

Course type:Practical **No. of Credits: 02(P)**

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MTS-304 MJ : Group Theory

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Define and identify algebraic structures such as groups and classify them (abelian,cyclic, permutation groups).
2. Analyze subgroup structures and apply subgroup criteria to solve problems.
3. Apply Lagrange's theorem to determine orders of elements and subgroups.
4. Examine permutation groups, cycles, and alternating groups and perform computations.
5. Explain and apply group homomorphisms, kernels, and factor groups in problem−solving.
6. Construct and analyze quotient groups and understand their algebraic significance.

Course Contents

Unit I : Groups – Definitions and Properties **(08 Lectures)**

1.1 Binary operations: Definition, closure property.

1.2 Algebraic structures and isomorphic binary structures.

1.3 Definition of a group.

1.4 Basic properties: identity, inverse, uniqueness

1.5 Examples of groups (finite and infinite).

Unit II : Subgroups **(06 Lectures)**

2.1 Definition of subgroup

2.2 Subgroup criteria

2.3 Cyclic groups: Definition and properties

2.4 Generators of cyclic groups

2.5 Order of an element

Unit III : Permutation Groups **(12 Lectures)**

3.1 Permutation groups and symmetric group S_n (n$\leq$3)

3.2 Orbits and their properties.

3.3 Cycles and cycle notation.

3.4 Even and odd permutations, alternating group A_n

3.5 Cosets and Lagrange's Theorem

3.6 Direct products of groups

Unit IV : Homomorphisms and Factor Groups **(12 Lectures)**

4.1 Group homomorphisms: Definition and examples

4.2 Kernel and image of a homomorphism

4.3 Properties of homomorphisms

4.4 Factor (quotient) groups

4.5 Computation of factor groups

4.6 Introduction to simple groups

Recommended Books:

1. John B. Fraleigh, A First Course in Abstract Algebra, Seventh Edition, Pearson. Sections: 2,3,4,5,6,8,9,10, 11(only Direct Product), 13,14,15. (Fundamental Theorem of Group Homomorphism (First Isomorphism Theorem) statement only), exclude inner automorphisms.)

Reference Books:

1. Topics in Algebra − I. N. Herstein
2. Abstract Algebra − David S. Dummit and Richard M. Foote
3. Contemporary Abstract Algebra − Joseph A. Gallian
4. An Introduction to the Theory of Groups − Joseph J. Rotman

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MTS-305MJ : Ordinary Differential Equations

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Solve linear differential equations with constant coefficients by applying characteristic equation methods for distinct, repeated, and complex roots.
2. Analyze and solve non-homogeneous linear differential equations using the method of undetermined coefficients, reduction of order, and variation of parameters.
3. Apply the inverse differential operator technique to evaluate particular integrals for algebraic, exponential, and trigonometric functions with logical justification.
4. Formulate and solve systems of first-order linear differential equations with constant coefficients arising in mathematical and physical models.
5. Examine the power series solutions of differential equations, including classification of ordinary and singular points, and construct series solutions about an ordinary point.
6. Understand the genesis of ordinary differential equations.

Course Contents

Unit 1 : Linear Differential Equations with constant coefficients (08 Hours)

1.1 Constant coefficient homogeneous equations

1.2 Characteristic equations: distinct real roots, repeated roots, complex roots

Unit 2 : Non−Homogeneous Linear Equations (06 Hours)

2.1 Method of undetermined coefficients

2.2 Method of reduction of order

2.3 Method of variation of parameters.

Unit 3 : Inverse differential operator (08 Hours)

3.1 The operator $\frac{1}{(f(D))}$ and its evaluation for the functions x^m, e^{ax}, $e^{ax}.V$, XV.

3.2 The operator $\frac{1}{(D^2+a^2)}$ acting on $sinax$ and $cosax$ with proofs.

Unit 4 : System of Equations (04 Hours)

4.1 Introduction to system of differential equations

4.2 Solution of homogeneous first order systems with constant coefficient

Unit 4 : Power Series Solutions (04 Hours)

5.1 Review the properties of power series

5.2 Classifications of ordinary and Singular points

5.3 Series solution near an ordinary point

Recommended Books:

1. Elementary Differential Equations seventh edition by Earl D. Rainville and Philip E Bedient.

   Chapater − 6, 33 to 37. Chapater − 7, 41. Chapater − 8, 44 to 45, Chapater − 9, 47 to 50. Chapater − 13, 76 to 81. Chapater − 17, 105 to 107.

Reference Books:

1. William F Trench, Elementary Differential Equations with Boundary Value Problems, E book (Free download)
2. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand and Company LTD 2009.
3. George F. Simmons and Stevan G. Krantz, Differential Equations, Tata McGraw-Hill.
4. W. R. Derrick and S. I. Grossman, A First Course in Differential Equations with Applications. CBS Publishers and Distributors, Delhi 110032, Third Edition.
5. Daniel Murray, Introductory Course in Differential Equations, Orient Longman.

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MTS-306 MJP : Practical on Group Theory and Ordinary Differential Equations

Course type:Practical **No. of Credits: 02(P)**

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MTS-310-ME : A) Graph Theory

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall basic definitions and concepts of graphs, including types of graphs, graph representations, and graph terminology.
2. Understand: Explain connectivity, trees, Eulerian and Hamiltonian graphs, and apply concepts like Prim's and Kruskal's algorithms.
3. Apply: Apply graph algorithms (Dijkstra's, Prim's, Kruskal's) to solve problems like minimum spanning tree and shortest path.
4. Analyze: Analyze graph properties (connectivity, planarity, chromatic number) and apply Hall's Theorem to solve matching problems.
5. Evaluate: Evaluate graph coloring, matching, and planarity, and apply concepts to real-world problems like Chinese postman and travelling salesman.
6. Create: Create graph models for real-world applications (chemistry, social networks, data science) and analyze their properties.

Course Contents

Unit 1 : Introduction to Graphs **(10 Hours)**

1.1 Basic definitions: vertices, edges, and degree.

1.2 Graphs as models: Königsberg seven bridge problem, job assignments, three utilities graphs, traffic networks

1.3 Types of graphs: directed, undirected, simple, multigraphs, complete graphs, bipartite Graphs, regular graphs, Petersen graph

1.4 More Definitions: Subgraphs, proper and spanning subgraphs, walk, paths and cycles, graph isomorphism, complement of a graph, edge deletion, vertex deletion, edge contraction, union and intersection of graphs, Matrix representation of graphs:Adjacency matrix, Incidence matrix

Unit 2 : Connectivity and Trees **(08 Hours)**

2.1 Connectivity: Connected graph, components, cut-vertex, bridges, matrix characterization of connectivity, 2-connected graphs

2.2 Trees: Definition, examples, properties, characterizations, binary trees

2.3 Spanning trees: Definition, Cayley's formula, minimum spanning tree in a weighted graph, Prim's algorithm, Kruskal's algorithm, Dijkstra's algorithm

Unit 3 : Eulerian and Hamiltonian Graphs **(08 Hours)**

3.1 Eulerian graphs: Walk, trail, Eulerian trail, Eulerian graph, Euler's Theorem, Examples of Eulerian graphs, characterization in terms of even degree, Cycle decomposition

3.2 Hamiltonian graphs: Hamiltonian graph, definition and examples, sufficient Conditions

3.3 Applications: Chinese postman problem, travelling salesman problem

Unit 4 : Introduction to Matching and Colouring (04 Hours)

4.1 Matching: Matchings, maximum matchings, augmenting path, Hall's Theorem (statement) and its applications

4.2 Graph coloring: Vertex colouring, chromatic number, chromatic number of some special graph, definition of planar graph, four color theorem (statement)

Unit 5 : Some applications of graphs: [For Practical purpose only]

5.1 Applications in Chemistry- Graph energy, Reaction Network

5.2 Applications in Social Networks- Introduction to social network analysis, Role in real-world systems

5.3 Applications in Data Science- Neural Networks, Page ranking

Reference Books:

1. A First Look at Graph Theory, John Clark & Derek Holton, Allied Publishers Ltd. 1991.
2. Graph Theory with Applications to Engineering & Computer Science, Narsingh Deo, Prentice−Hall of India, 1974.
3. Introduction to Graph Theory (2nd Edition), Douglas West, Pearson Education (India), 2015.
4. Introduction to Graph Theory, Robin Wilson, Prentice Hall / Addison-Wesley, 1996.
5. Introduction to Chemical Graph Theory, Stephan Wagner & Hua Wang, CRC Press 2018.
6. Social Network Analysis, Tanmoy Chakraborty, Wiley India Pvt. Ltd. 2021.
7. Neural Networks and Deep Learning: A Textbook, Charu Aggarwal, Springer International Publishing AG, 2018.
8. Nine Algorithms That Changed the Future: The Ingenious Ideas That Drive Today's Computers, John MacCormick, Princeton University Press, 2012.

Other Resources:

- NPTEL Course on basic graph theory conducted by IISER, Pune: https://nptel.ac.in/courses/111106102
- NPTEL Course on graph theory conducted by IIT Madras, https://nptel.ac.in/courses/111106050
- Online Free Software: http://graphtheorysoftware.com

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MTS-310 ME : B) Linear Programming Problem and Game Theory

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall concepts of linear programming, transportation, assignment, and game theory, including methods like Simplex, Big-M, and Hungarian.
2. Understand: Explain formulations and assumptions of linear programming, transportation, and assignment problems, and characteristics of game theory.
3. Apply: Apply methods like Simplex, Big-M, North West Corner Rule, VAM, MODI, and Hungarian to solve linear programming, transportation, and assignment problems.
4. Analyze: Analyze duality in linear programming, degeneracy in transportation, and optimal strategies in game theory.
5. Evaluate: Evaluate solutions to linear programming, transportation, assignment problems, and determine optimal strategies and value of games.
6. Create: Formulate and solve real−world problems using linear programming, transportation, assignment, and game theory concepts, and apply methods like graphical and dominance methods.

Course Contents

Unit 1 : Linear Programming Problems **(10 Hours)**

1.1 Basic concepts of linear programming problem

1.2 Assumptions and limitations of linear programming problem.

1.3 Slack, Surplus variable and standard form of Simplex method.

1.4 Artificial variable and Big−M method.

1.5 Types of solutions of linear programming problems.

1.6 Duality in linear programming problem

Unit 2 : Transportation Problems **(08 Hours)**

2.1 Mathematical model of transportation problem.

2.2 Linear programming formulation of transportation problem.

2.3 Initial basic solution of transportation problem.

(a)North West Corner Rule.

(b)Lowest Cost Entry Method.

(c) Vogel's Approximation Method (VAM)

2.4 Optimal solution by Modified Distribution Method (MODI Method).

2.5 Degeneracy in transportation problem

Unit 3 : Assignment Problems **(06 Hours)**

3.1 Mathematical model of assignment problem.

3.2 Linear programming formulation of assignment problem.

3.3 Hungarian method for solving assignment problem.

Unit 4 : Game Theory **(06 Hours)**

4.1 Characteristics of Game Theory.

4.2 Saddle point, optimal strategies and value of the game.

4.3 Rectangular games without saddle point and Game as a L.P.P. formulation

(a) Algebraic Method.

(b) Graphical Method for $2 \times n$ and $m \times 2$ games.

(c) Dominanace Method for $m \times n$ game.

Text Book:
Operations Research, S.D. Sharma, Kedar Nath Ram Nath and Co, meerut, Eighteenth Edition, 2017.
Reference Book:

1. Hamdy A. Taha, Operations Research, (Eighth Edition, Prentice Hall of India), 2008.
2. Operations Research: Theory and Applications, J. K. Sharma, Macmillan India Ltd., Fifth Edition, 2013.
3. P. K. Gupta and D. S. Hira, Operations Research, (Fifth Edition, S. Chand), 2014.

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MTS-311 MEP : A) Practical on Graph Theory
or
MTS-311 MEP : B) Practical Linear Programming Problem and Game Theory

Course type:Practical **No. of Credits: 02**

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MTS-321-VSC Mathematical Statistics

Course type:Practical **No. of Credits: 02**

Course Outcomes: Students will able to

1. To understand the concept of probability theory, random variables, and probability distributions (discrete and continuous).
2. To Apply mathematical techniques to derive probability distributions of random variables and study their properties.
3. To analyze different sampling distributions and explain their role in statistical inference.
4. To Formulate and evaluate point and interval estimation methods.
5. To Develop and apply hypothesis testing procedures using classical based approaches.
6. To create methodologies to understand various statistical methods.

Course Contents

Unit 1 : Introduction to Probability & Random Variables (12 Hours)

1.1 Sample space, events, probability of an event, addition and multiplication theorem of probability, conditional probability. Numerical problems

1.2 Concept of a random variable, discrete probability distribution, continuous Probability distribution, joint probability distribution.

1.3 Independent random variables, Mean of a random variables, Variance and Covariance, Mean and variance of linear combinations of random variables

Unit 2 : Some Standard Discrete & Continuous Probability Distributions (16 Hours)

2.1 Bernoulli, Binomial, Poisson distribution, Negative binomial distribution, Geometric distribution,

2.2 Continuous Uniform distribution, Normal distribution, Central Limit Theorem, Gamma distribution, Exponential distribution, Chi − squared distribution, Student's t− distribution, F distribution, Chi square distribution.

Unit 3 : Testing of Hypothesis (20 Hours)

3.1 basics of testing of hypothesis, Parameter, Parameter Space, Statistic, Null & Alternative hypotheses, level of significance, errors in testing of hypothesis, Type I & Type II errors, meaning of test, types of test , Test Statistic, Critical region , P−value, decision by critical region and P− value criteria.

3.2 Statistical Tests: Large sample & Small sample tests.

Unit 4: Correlation & Regression Models (12 Hours)

4.1 concepts of correlation, scattered diagram, Karl Pearson's Coefficient of Correlation, properties & interpretation of Correlation coefficient.

4.2 Simple Linear Regression Model, Least square principle, fitting of linear regression model, estimation of parameters.

4.3 Multiple Linear Regression Model, estimation of parameters by least square Method of estimation.

Reference Books:

1. Ross, Sheldon M. Introduction to probability and statistics for engineers and scientists. Academic press, 2020.
2. Gupta, S.C. and Kapoor, V. K. (2020). Fundamentals of Mathematical Statistics, Tenth edition Sultan Chand and Sons Publishers, New Delhi
3. Hogg, Robert V., Elliot A. Tanis, and Dale L. Zimmerman. Probability and statistical inference. Vol. 993. New York: Macmillan, 1977.

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MTS-331-FP : Field Project

Course type:Practical **No. of Credits: 02**

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MTS-341-MN : A) Integral Transform

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of Laplace transforms, Fourier series, and Fourier transforms, including standard formulas and theorems.
2. Understand: Explain concepts of piecewise continuous functions, exponential order, and Dirichlet conditions, and apply them to Laplace and Fourier transforms.
3. Apply: Apply Laplace transforms to solve linear differential equations, and use Fourier series to represent periodic functions.
4. Analyze: Analyze properties of Laplace and Fourier transforms, including shifting theorems and convergence of Fourier series.
5. Evaluate: Evaluate Laplace transforms of derivatives, inverse Laplace transforms, and Fourier transforms of standard functions.
6. Create: Apply Laplace and Fourier transforms to solve real-world problems, including initial value problems and periodic function representations.

Course Contents

Unit 1 : Basic Introduction **(04 Hours)**

1.1 Review of improper integrals

1.2 piecewise continuous functions

1.3 functions of exponential order

1.4 motivation and basic idea of integral transforms.

Unit 2 : Laplace Transform **(06 Hours)**

2.1 Definition of Laplace transform, linearity property, Laplace transform of standard functions

2.2 First and second shifting theorems, inverse Laplace transform using standard tables.

Unit 3 : Applications of Laplace Transform **(06 Hours)**

3.1 Laplace transform of derivatives

3.2 Solution of first-order and second-order linear differential equations

3.3 Initial value problems, unit step (Heaviside) function.

Unit 4 : Fourier Series and Fourier Transform **(08 Hours)**

4.1 Periodic functions, Fourier series

4.2 Dirichlet conditions (statement), Fourier sine and cosine series

4.3 Half-range expansions, Fourier transform and inverse Fourier transform, basic properties.

Unit 5:Applications of Fourier Series and Fourier Transform **(06 Hours)**

5.1 Fourier series of simple periodic functions

5.2 sine and cosine series problems

5.3 Fourier transform of standard functions, illustrative examples and interpretation.

Recommended Book:

1. INTEGRAL TRANSFORMS AND THEIR APPLICATIONS, 3rd Edition, Lokenath Debnath, Dambaru Bhatta

   Unit 1: Chapter 1: Sec- 1.1, 1.4, Chapter 3: Sec- 3.3

   Unit 2: Chapter 3: Sec- 3.2, 3.4, 3.7

   Unit 3: Chapter 3: Sec- 3.6, Chapter 4: Sec- 4.2,

   Unit 4: Chapter 1: Sec- 1.2, Chapter 2: Sec- 2.2 to 2.5, 2.13- 2.14

   Unit 5: Chapter 2: Sec- 2.10 to 2.15

Reference Book:

1. B. L. Gupta − Integral Transforms

2. M. R. Spiegel − Laplace and Fourier Transforms (Schaum's Outline)

3. E. Kreyszig − Advanced Engineering Mathematics

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MTS-341 MN : B) Operations Research

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall concepts of linear programming, transportation, and assignment problems, including methods like Simplex, Big-M, and Hungarian.
2. Understand: Explain formulations and mathematical models of linear programming, transportation, and assignment problems.
3. Apply: Apply methods like Simplex, Big−M, North West Corner Rule, VAM, MODI, and Hungarian to solve linear programming, transportation, and assignment problems.
4. Analyze: Analyze types of solutions and optimality of linear programming, transportation, and assignment problems.
5. Evaluate: Evaluate solutions to linear programming, transportation, and assignment problems using Python programming.
6. Create: Formulate and solve real-world problems using linear programming, transportation, and assignment models, and implement solutions using Python.

Course Contents

Unit 1 : Linear Programming Problem **(12 Hours)**

1.1 Basic concepts of linear programming problem

1.2 Slack, Surplus variable and standard form of Simplex method.

1.3 Artificial variable and Big−M method.

1.4 Types of solutions of linear programming problems.

1.5 Linear programming in Python Programming.

Unit 2 : Transportation Problem **(10 Hours)**

2.1 Mathematical model of transportation problem.

2.2 Linear programming formulation of transportation problem.

2.3 Initial basic solution of transportation problem.

(a)North West Corner Rule.

(b)Lowest Cost Entry Method.

(c) Vogel's Approximation Method (VAM)

2.4 Optimal solution by Modified Distribution Method (MODI Method).

2.5 Transportation Problem in Python Programming

Unit 3 : Assignment Problem **(08 Hours)**

3.1 Mathematical model of assignment problem.

3.2 Linear programming formulation of assignment problem.

3.3 Hungarian method for solving assignment problem.

3.4 Assignment Problem in Python Programming.

Reference Book:

1. Operations Research, S.D. Sharma, Kedar Nath Ram Nath and Co, meerut, Eighteenth Edition, 2017.
2. Python Programming: Introduction to Computer Science by Zelle, J. Franklin, Beedle & Associates Inc.
3. Hamdy A. Taha, Operations Research, (Eighth Edition, Prentice Hall of India), 2008.
4. Operations Research: Theory and Applications, J. K. Sharma, Macmillan India Ltd., Fifth Edition, 2013.
5. P. K. Gupta and D. S. Hira, Operations Research, (Fifth Edition, S. Chand), 2014.

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T. Y. B. Sc. (Semester−VI)

MTS 351 MJ : Complex Analysis

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of complex numbers, analytic functions, and elementary functions, including Cauchy−Riemann equations and contour integrals.
2. Understand: Explain concepts of limits, continuity, differentiability, and analyticity of complex functions, and apply Cauchy's integral formula.
3. Apply: Apply techniques of contour integration, residues, and poles to evaluate complex integrals and series expansions.
4. Analyze: Analyze properties of analytic functions, including harmonic functions, and apply Liouville's Theorem and Fundamental Theorem of Algebra.
5. Evaluate: Evaluate complex integrals using Cauchy's integral formula, residues, and poles, and determine convergence of sequences and series.
6. Create: Apply complex analysis techniques to solve problems in physics, engineering, and mathematics, involving complex functions and integrals.

Course Contents

Unit 1 : Analytic functions **(08 Hours)**

Functions of a Complex Variables, Limits, Theorems on limits (Without Proof), Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulas (Without Proof), Cauchy−Riemann Equations, Sufficient Conditions for differentiability (Only Statement and Examples), Polar coordinates, Analytic functions, Harmonic functions.

Unit 2 : Elementary Functions **(04 Hours)**

The Exponential functions, The Logarithmic function, Branches and derivatives of logarithms, some identities involving logarithms, Complex exponents, Trigonometric functions.

Unit 3 : Integrals **(08 Hours)**

Derivatives of functions, Definite integrals of functions, Contours, Contour integral, Examples, Upper bounds for Moduli of contour integrals, Anti-derivatives (Only Examples), Cauchy−Goursat Theorem, Simply and multiply Collected domains. Cauchy integral formula, Derivatives of analytic functions. Liouville's Theorem and Fundamental Theorem of Algebra.

Unit 4 : Series **(04 Hours)**

Convergence of sequences and series, Taylor's series (without proof), Laurent series (without proof), examples.

Unit 5 : Residues and Poles **(06 Hours)**

Isolated singular points, Residues, Cauchy residue theorem (Without Proof), residue at infinity,

types of isolated singular points, residues at poles, zeros of analytic functions, zeros and poles.

Recommended Book:
J.W. Brown and R.V. Churchill, Complex Variables and Applications, International Student Edition, 2009. (Eighth Edition).
Chapter 2: §12, §15 to §26, Chapter 3: §29 to §34, Chapter4: §37 to §44, §46 and §48 to §53.

Chapter:5 §55 to §60 and §62.Chapter 6: §68 to §76.

Reference Books:

1. S. Ponnusamy, Complex Analysis, Second Edition (Narosa).
2. S. Lang, Complex Analysis, (Springer Verlag).
3. A.R. Shastri, An Introduction to Complex Analysis, (MacMillan).
4. L.V.Ahlfors, Complex Analysis, 3rd edition, McGraw Hill, 2000.
5. H.A.Priestley, Introduction to Complex Analysis, 2nd edition (Indian), Oxford, 2006.

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MTS 352 MJ : Real Analysis-II

Course type:Theory **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of Riemann integral, improper integrals, and convergence of sequences and series of functions.
2. Understand: Explain concepts of measure zero sets, pointwise and uniform convergence, and apply fundamental theorem of integral calculus.
3. Apply: Apply tests for convergence and divergence of improper integrals, and evaluate Riemann integrals using properties and fundamental theorem.
4. Analyze: Analyze uniform convergence of sequences and series of functions, and consequences of uniform convergence.
5. Evaluate: Evaluate improper integrals, and determine convergence and uniform convergence of series of functions.
6. Create: Apply Riemann integration and convergence concepts to solve problems in analysis, and investigate properties of functions defined by integrals or series.

Course Contents

Unit 1 : Riemann Integral **(10 Hours)**

1.1 Sets of measure zero,

1.2 Definition of Riemann integral

1.3 Existence of Riemann integral

1.4 properties of Riemann integral

1.5 Fundamental theorem of integral calculus

Unit 2 : Improper Integrals **(06 Hours)**

2.1 Improper integrals of first kind

2.2 Convergence, divergence, absolute and conditional convergence

2.3 Integral test for convergence of series

2.4 Improper integrals of second kind, Cauchy principal value.

Unit 3 : Sequences of functions **(08 Hours)**

3.1 Point wise convergence of sequences of functions

3.2 Uniform convergence of sequences of functions

3.3 Consequences of uniform convergence

Unit 4 : Series of functions **(06 Hours)**

4.1 Convergence and uniform convergence of series of functions

4.2 Integration and differentiation of series of functions.

Recommended Books:

R. R. Goldberg, Methods of Real Analysis, Oxford and I.B.H. Publication Co.,1970
Ch. 7: 7.1 to 7.4 and 7.8,7.9,7.10 ; Ch. 9, Art 9.1 to 9.5

Reference Books:

1. First course in mathematical analysis, D somsundaram, B Chuadhari, Narosa Publishing house 2009.
2. Robert, G. Bartle, Donald Sherbert − Introduction to real analysis, Third edition, John Wiley and Sons.
3. Shantinarayan and Mittal − A course of Mathematical Analysis, Revised edition, S. Chand and Co.(2002).
4. S.C. Malik and Savita Arora − Mathematical Analysis , New Age International Publications,Third Edition,(2008).

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MTS-353 MJP : Practical on Complex Analysis and Real Analysis-II

Course type:Practical **No. of Credits: 02**

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MTS-354-MJ : Ring Theory

Course type:Major **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and properties of rings, fields, integral domains, and polynomial rings.
2. Understand: Explain concepts of divisors of zero, characteristics of a ring, and field of quotients of an integral domain.
3. Apply: Apply evaluation homeomorphisms, division algorithm, and factorization techniques in polynomial rings.
4. Analyze: Analyze properties of ideals, factor rings, and homomorphism, and apply fundamental homomorphism theorem.
5. Evaluate: Evaluate properties of unique factorization domains, principal ideal domains, and Euclidean domains.
6. Create: Apply concepts of rings and fields to solve problems in algebra, including factorization and ideal structure, and investigate properties of Gaussian integers.

Course Contents

Unit 1 : Rings and Fields **(06 Hours)**

1.1 Ring, Subring, Fields.

1.2 Divisors of zero, Integral Domain, The Characteristics of a Ring.

1.3 The Field of Quotients of an Integral Domain.

Unit 2 : Rings of Polynomials & Factorization **(07 Hours)**

2.1 Polynomials in an determinate.

2.2 The Evaluation Homomorphisms.

2.3 Factorization of a Polynomial over a Field: The Division Algorithm in F[x]

2.4 Irreducible Polynomials, Uniqueness of Factorization in F[x].

Unit 3 : Ideals and Factor Rings **(07 Hours)**

3.1 Homomorphism, Properties of Homomorphism

3.2 Ideals, Factor Ring, Fundamental Homomorphism Theorem.

3.3 Maximal Ideal, Prime Ideal, Ideal Structure in F[x].

Unit 4 : Factorization **(10 Hours)**

4.1 Unique Factorization Domain, Principal Ideal Domain, Gauss Lemma, $D[x]$ is a UFD.

4.2 Euclidean Norm, Euclidean Domain, Euclidean Algorithm (Without Proof).

4.3 Gaussian Integers, Multiplicative Norm.

Recommended Book:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson.

   Unit 1: Section 18, 19, 21.

   Unit 2: Section 22 and 23.

   Unit 3: Section 26 and 27.

   Unit 4: Section 45, 46 and 47 (except theorem 47.10).

Reference Books:

1. Josheph A. Gallian, Contemporary Abstract Algebra, 7th Edition, Narosa Publishing House.
2. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Edition, Jonh Wiley and Sons, Inc.
3. I.N. Herstein, Abstract Algebra, 3rd Edition, Prentice Hall of India.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, 2nd Edition,Cambridge University Press.

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MTS -355-MJ : Partial Differential Equations

Course type:Major **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall definitions and concepts of ordinary and partial differential equations, including surfaces, curves, and Pfaffian differential forms.
2. Understand: Explain methods of solving simultaneous differential equations, linear equations of first order, and origin of partial differential equations.
3. Apply: Apply methods of solving partial differential equations, including separation of variables, to solve Laplace and wave equations.
4. Analyze: Analyze properties of linear partial differential equations with constant coefficients, and classify second − order partial differential equations.
5. Evaluate: Evaluate solutions of reducible and irreducible linear partial differential equations, and determine integral surfaces passing through given curves.
6. Create: Apply knowledge of partial differential equations to model and solve real − world problems, including physical and engineering applications.

Course Contents

Unit 1 : Introduction to Ordinary and Partial Differential Equations (07 Hours)

1.1 Surfaces and curves in three dimensions

1.2 Simultaneous differential equations of the first order and the first degree in three variable.

1.3 Methods of solution of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$

1.4 Pfaffian differential forms and equations.

1.5 Solution of Pfaffian differential equations in three variables

Unit 2 : Partial Differential Equations (08 Hours)

2.1 Introduction to Partial Differential Equations

2.2 Origin of first order Partial Differential Equations

2.3 Linear equations of first order equations

2.4 Integral surfaces passing through given curve

Unit 3 : Second Order Partial Differential Equations (08 Hours)

3.1 The Origin of Second Order Partial Differential Equations.

3.2 Linear Partial Differential Equations with constant coefficients.

3.3 Methods of solving Linear Partial Differential Equations

3.3.1. Solution of reducible equations

3.3.2. Solution of irreducible equations with constant coefficients

Unit 4 : Classification of Partial Differential Equations (07 Hours)

4.1 Classification of second order partial differential equations, canonical forms

4.2 Solution of Laplace equations by separation variables methods

4.4 Solution of wave equation by separation variables method.

Recommended Books:

1. Ian Sneddon, Element of Partial Differential Equations, McGraw−Hill Book Company, McGraw−Hill Book Company.

   Unit−1: Chapter−1 : 1,2,3,5

   Unit−2: Chapter−2 :1,2,4,5

   Unit−3:Chapter−3: 1,4,5

2. J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists,second Edition, Narasa Publications.

   Unit − 4: Chapter No.3: 3.3, Chapter No.4: 4.3 ,Chapter No.5: 5.5

Reference Books:

1. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing,House 2nd Edition, 2003 (Reprint, 2006).

2. K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI.

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MTS-356-MJP : Practical on Ring Theory and Partial Differential Equations

Course type:Practical **No. of Credits: 02**

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MTS-360- ME : A) Numerical Methods

Course type:Major Elective **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall numerical methods for root finding, interpolation, differentiation, integration, and solving ODEs, including formulas and algorithms.

2. Understand: Explain concepts of errors, convergence, and stability in numerical methods, and apply finite difference operators.

3. Apply: Apply numerical methods like bisection, Newton−Raphson, interpolation formulas, and Runge−Kutta methods to solve problems.

4. Analyze: Analyze accuracy and efficiency of numerical methods, and choose suitable methods for specific problems.

5. Evaluate: Evaluate numerical solutions of equations, derivatives, and integrals using methods like Simpson's rules and Taylor's series.

6. Create: Develop numerical solutions to real−world problems involving ODEs, interpolation, and optimization using Python or other tools.

Course Contents

Unit 1 : Foundations of Numerical Methods **(06 Hours)**

1.1 Mathematical Preliminaries for Numerical Methods

1.2 Errors and their computations

1.3 Bisection Method

1.4 Method of False Position

1.5 Iteration Method

1.6 Newton−Raphson Method

Unit 2 : Interpolation (08 Hours)

2.1 Finite Difference Operators and their relations (Forward Difference, Backward Difference and Shift Operator)

2.2 Differences of a polynomial

2.3 Newton's Forward Interpolation

2.4 Newton's Backward Interpolation

2.5 Lagrange's Interpolation

Unit 3 : Numerical Differentiation and Integration (08 Hours)

3.1 Numerical Differentiation (First and Second Derivative)

i) Using Newton's Forward Differences

ii) Using Newton's Backward Differences

3.2 Numerical Integration

i) Trapezoidal Rule

ii) Simpson's $\frac{1}{3}^{rd}$ Rule

iii) Simpson's $\frac{3}{8}^{th}$ Rule

Unit 4 : Numerical Solution of first order ordinary differential equations (08 Hours)

4.1 Taylor's Series Method

4.2 Picard's Method

4.3 Euler's Method

4.4 Modified Euler's Method

4.5 Runge−Kutta 2^{nd} order Method

4.6 Runge−Kutta 4^{th} order Method (Without derivation)

Recommended Book:

1. Introductory Methods of Numerical Analysis (Fourth Edition), S. S. Sastry, PHI Learning Private Limited, 2009.

   1) Section: 1.2, 1.3, 2.1, 2.2, 2.3, 2.4 (without Aitken's Δ^2-process.), 2.5 (without generalized Newton's method)

   2) Section: 3.3 (without central difference), 3.5, 3.6. 3.9.1

   3) Section: 5.1, 5.2 (without 5.2.1, 5.2.2), 5.4, 4.4.1, 5.4.2, 5.4.3

   4) Section: 7.1, 7.2, 7.3, 7.4 (without 7.4.1), 7.4.2, 7.5 (without derivation for the fourth order)

Reference Books:

1. K. E. Atkinson − Numerical Analysis (John Wiley)

2. R. L. Burden & J. D. Faires − Numerical Analysis

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MTS-360-ME : B) Computational Geometry

Course type:Major Elective **No. of Credits: 02**

Course Outcomes: Students will able to

1. Remember: Recall concepts of 2D and 3D transformations, projections, and curve representations, including matrices and homogeneous coordinates.
2. Understand: Explain transformations like rotation, scaling, and translation, and apply them to points, lines, and shapes.
3. Apply: Apply transformation techniques to perform solid body transformations, projections, and generate curves like circles and ellipses.
4. Analyze: Analyze properties of transformations, projections, and curves, including affine and perspective transformations.
5. Evaluate: Evaluate representations of curves and surfaces, including Bezier and B−spline curves, and determine suitable transformations.
6. Create: Create 2D and 3D models using transformations, projections, and curve representations, and visualize them using computer graphics.

Course Contents

Unit 1 : Two dimensional transformations **(08 Hours)**

1.1 Introduction.

1.2 Representation of points.

1.3 Transformations and matrices.

1.4 Transformation of points.

1.5 Transformation of straight lines.

1.6 Midpoint transformation.

1.7 Transformation of parallel lines.

1.8 Transformation of intersecting lines.

1.9 Transformation: rotations, reflections, scaling, shearing.

1.10 Combined transformations.

1.11 Transformation of a unit square.

1.12 Solid body transformations.

1.13 Transformation and homogeneous coordinates. Translation.

1.14 Reflection through arbitrary line

1.15 Rotation about an arbitrary point.

Unit 2 : Three dimensional transformations **(06 Hours)**

2.1 Introduction.

2.2 Three dimensional−Scaling, shearing, rotation, reflection, translation.

2.3 Rotation about − an axis parallel to coordinate axes, an arbitrary axis in space.

2.4 Reflection through−

i) coordinate planes,

ii) planes parallel to coordinate planes,

iii) arbitrary planes.

Unit 3 : Projections **(06 Hours)**

3.1 Introduction

3.2 Affine and perspective transformations.

3.3 Orthographic projections.

3.4 Axonometric projections.

3.5 Oblique projections.

3.6 Single point perspective transformations.

3.7 Vanishing point

Unit 4 : Plane Curves **(06 Hours)**

4.1 Introduction.

4.2 Curve representation.

4.3 Non−parametric curves.

4.4 Parametric curves.

4.5 Parametric representation of a circle and generation of circle.

4.6 Parametric representation of an ellipse and generation of ellipse.

4.7 Parametric representation of a parabola and generation of parabolic Segment.

4.8 Parametric representation of a hyperbola and generation of hyperbolic segment

Unit 5 : Space curves **(04 Hours)**

5.1 Bezier Curves −Introduction, definition, properties (without proof),

5.2 Curve fitting (up to $n = 3$), equation of the curve in matrix form (upto $n = 3$)

5.3 B−spline curves−introduction, definition, properties (without proof).

Recommended Books:

1. D. F. Rogers, J. A. Adams, Mathematical elements for Computer graphics, Mc Graw Hill Intnl Edition.

   Chapter 2: Sec. 2.1 to 2.20,

   Chapter 3: Sec. 3.1 to 3.10. Sec. 3.12 to 3.15,

   Chapter 4: Sec. 4.1, 4.2, 4.4, 4.5,

   Chapter 5: Sec. 5.1, 5.8.

Reference Books:

1. Computer Graphics with OpenGL, Donald Hearn, M. Pauline Baker, Warren Carithers,Pearson (4th Edition)
2. Schaum Series, Computer Graphics by Zhigang Xiang and Roy A. Plastock.

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MTS-361 MEP : A) Practical on Numerical Methods
Or
MTS-361 MEP : B) Practical on Computational Geometry

Course type:Practical **No. of Credits: 02**

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MTS-371-VSC : Data Science

Course type:VSC **No. of Credits: 02(P)**

Course Outcomes: Students will able to

1. Remember: Recall concepts of data science, Python programming, linear algebra, and data visualization, including data types, libraries, and plot types.
2. Understand: Explain data science workflow, Python basics, vector and matrix operations, and principles of data visualization.
3. Apply: Apply Python programming, linear algebra techniques, and data visualization tools to analyze and represent data.
4. Analyze: Analyze data using statistical methods, handle missing values, and interpret results of hypothesis testing and visualizations.

5. Evaluate: Evaluate data science models, visualizations, and results, and communicate insights effectively.
6. Create: Create data science projects using Python, incorporating data handling, statistical analysis, and visualization to solve real-world problems.

Course Contents

Unit I : Introduction to Data Science **(04 Hours)**

- Definition and scope of Data Science
- Data Science workflow
- Types of data and data sources
- Role of Mathematics, Statistics, and Linear Algebra in Data Science
- Applications of Data Science
- Preliminaries of Excel for Data Science

Unit II : Python Programming for Data Science **(07 Hours)**

- Python environment: Anaconda, Jupyter Notebook
- Python basics:
  - –Variables and data types
  - –Lists, tuples, sets, dictionaries
  - –Conditional statements and loops
- Functions and modules
- File handling (CSV, text files)
- Introduction to scientific libraries overview

Unit III : Linear Algebra for Data Science **(07 Hours)**

- Vectors and vector operations
- Matrices and matrix operations, Matrix transpose, inverse, rank
- Systems of linear equations and matrix representation
- Eigenvalues and eigenvectors
- Eigen−Decomposition
- Diagonalization, Singular Value Decomposition
- Data representation and system of equations
- Applications of Linear Algebra in data representation

Unit IV : Data Handling and Statistical Analysis **(07 Hours)**

- Data loading and pre-processing using Pandas
- Handling missing values and outliers
- Descriptive statistics: mean, median, variance, standard deviation
- Correlation and covariance
- Basic probability distributions (normal, binomial, Poisson)
- Introduction to hypothesis testing (t−test, chi−square)

Unit V : Data Visualization **(05 Hours)**

- Principles of data visualization
- Data visualization using Python:
  - –Matplotlib
  - –Seaborn (basic usage)
- Plot types: bar, line, histogram, box plot, scatter plot
- Interpretation of visual results
- Preparing a short data analysis report

Reference Books:

1. VanderPlas J., Python Data Science Handbook, O'Reilly.
2. McKinney W., Python for Data Analysis, O'Reilly.
3. Deisenroth et al., Mathematics for Machine Learning, Cambridge.
4. David C. Lay, Linear Algebra and Its Applications, Pearson.
5. Montgomery & Runger, Applied Statistics, Wiley.
6. Joel Grus, Data Science from Scratch, O'Reilly.
7. Gilbert Strang −Linear Algebra and Its Applications

Online Resources:

- https://youtu.be/EbU0pZZvmQc?si=SgfCXXk6oDZkSY-3
- https://youtu.be/ehwt18bt3h8?si=fBo5kOWYSEMJAzpW
- https://youtu.be/bPrmA1SEN2k?si=YLXCEs6YQuGfC7_v
- https://youtu.be/NrpG0AexIEs?si=5rnWF4Kz-lXrVPwv

Practical 1

Foundations of Data Science and Spreadsheet Practice

Part A: Basic concepts

1. Write the definition of Data Science. List at least five fields where Data Science is used.
2. Identify a real-life problem and explain how Data Science can help solve it.
3. Draw and label the complete Data Science lifecycle. Explain each stage using an example dataset.
4. Explain the types of data: structured, semi-structured, and unstructured.
5. Explain why statistics is important in data analysis.
6. Give three examples where linear algebra is used in Data Science.

Part B: Excel worksheet on employees

1. Create a worksheet containing details of 25 employees with the following columns: Employee Name, Department, Basic Salary, Bonus, and Total Salary (calculated using a formula).
    - Find the total salary payout of all employees using the SUM function.
    - Calculate the average salary using AVERAGE.
    - Identify the highest salary using MAX.
    - Identify the lowest salary using MIN.
    - Sort the data in ascending order based on Total Salary.
    - Sort the data in descending order based on Total Salary.
    - Apply a filter to display only those employees whose Total Salary is above Rs. 50,000.
    - Create a column chart showing Employee Name and Total Salary.
    - Create a pie chart showing salary distribution department−wise.

Part C: Excel worksheet on students

1. 1. Perform the following tasks in Excel for a dataset of 20 students and their marks:
    - Create the dataset.
    - Apply the formulas SUM, AVERAGE, MAX, and MIN.
    - Sort the data in ascending and descending order.
    - Apply a filter to show students scoring above 75.
    - Create a bar chart and a pie chart.

Practical 2

Python Fundamentals, File Handling, NumPy, and Pandas

Part A: Python fundamentals with student data

1. Create a dataset using a list of dictionaries for student records with the following fields: Name, Marks, Age, and Grade.
    - Print all student names.
    - Find the highest marks using a loop.

- Count the number of students scoring above 75.
- Write a function to calculate average marks.
- Assign grade using conditional statements.
- Store unique grades using a set.

Part B: CSV file handling and libraries

1. Create a CSV file named sales.csv (dataset may be prepared manually or taken from Kaggle) containing the columns: Product, Quantity, and Price.
   - Read the CSV file.
   - Display all records.
   - Calculate total sales for each product.
   - Find the product with the highest revenue.
   - Save the results to a new text file.
   - Use NumPy to compute the mean price and the standard deviation of quantity.
   - Use Pandas to load the dataset and display summary statistics.

Practical 3

Vector and Matrix Computations

1. Create the vectors: V1 = (3, -1, 2) and V2 = (1, 4, -2).
2. Compute the following:
   - Vector addition
   - Dot product
   - Magnitude of vectors
   - Angle between vectors
3. Create the matrix A shown below and perform the given operations:

$$A = \begin{bmatrix} 2 & 1 & 3 \\ 1 & 0 & 2 \\ 4 & 1 & 8 \end{bmatrix}$$

4. Find the following for matrix A:
   - Transpose
   - Determinant
   - Rank
   - Inverse (if it exists)
5. Verify whether the columns of matrix A are linearly independent.
6. Write the following system in the form $AX = B$ using NumPy:

$$\begin{aligned} x + y + z &= 6 \\ 2x + 3y + z &= 14 \\ x - y + 2z &= 2 \end{aligned}$$

Practical 4

Eigenvalues, Systems, and SVD

1. **Solve using matrix method**

$$\begin{aligned} 2x + y + z &= 7 \\ x + 3y + 2z &= 13 \\ 3x + y + 4z &= 17 \end{aligned}$$

Steps:

   1. Write the system as $AX = B$.
   2. Solve using inverse or Gaussian elimination.
   3. Verify the solution.

2. **For matrix B**

$$B = \begin{bmatrix} 5 & 2 \\ 2 & 2 \end{bmatrix}$$

   1. Find eigenvalues.
   2. Find eigenvectors.
   3. Verify the eigen equation.

3. **Compute SVD of matrix C using Python/NumPy**

$$C = \begin{bmatrix} 1 & 0 \\ 0 & 2 \\ 2 & 0 \end{bmatrix}$$

   1. Identify U, $\sum$ and V^T
   2. Explain the significance of the largest singular value.

Practical 5

Data Loading, Cleaning, and Preprocessing

1. Load a CSV dataset (from Kaggle) using Pandas.
2. Display the first 5 rows, last 5 rows, and dataset information.
3. Identify missing values.
4. Handle missing data using mean substitution, median substitution, and row removal.
5. Detect duplicate rows and remove them.
6. Identify outliers and remove or cap them.
7. Compare dataset statistics before and after cleaning.
8. Calculate mean, median, mode, variance, and standard deviation.
9. Compare the mean and median for each column.
10. Compute the correlation matrix.

11. Compute the covariance matrix.
12. Identify the strongest correlated variables.
13. Create a scatter plot for correlated variables.

Practical 6

Probability Distributions and Introduction to Hypothesis Testing

1. Generate random data for the Normal, Binomial, and Poisson distributions.
2. Plot each distribution and compare their shapes.
3. Perform the following tasks using Python (NumPy / SciPy / Matplotlib) for a Normal distribution with mean (μ) = 50 and standard deviation (σ) = 10:
   - Compute the Probability Density Function (PDF) at $x = 60$.
   - Compute the mean.
   - Compute the variance.
   - Plot the Normal distribution curve.
4. Consider a Binomial experiment with number of trials $n = 10$ and probability of success $p = 0.5$. Compute the following:
   - Probability Mass Function (PMF) for exactly 6 successes.
   - Mean.
   - Variance.
   - Plot the Binomial distribution graph.
5. Assume the average number of customer arrivals per hour is 4. Compute the following for a Poisson distribution:
   - Probability Mass Function (PMF) for exactly 3 arrivals.
   - Mean.
   - Variance.
   - Plot the Poisson distribution graph.

Practical 7

Hypothesis Testing

Question 1: One−Sample t−test

A juice company claims that the average volume of juice in its bottles is 500 ml. A quality analyst collects a sample of 16 bottles and finds the sample mean volume to be 492 ml with a sample standard deviation of 12 ml. Test whether the company's claim is true at the 5% significance level. Null Hypothesis: $H_0 : \mu = 500$ Alternative Hypothesis: $H_a : \mu \neq 500$

Question 2: Independent t−test

A researcher wants to compare the marks of students from Class A and Class B. A sample of 10 students from each class is taken.
Class A: mean = 72, standard deviation = 8
Class B: mean = 78, standard deviation = 6
Test whether there is a significant difference between the average marks of the two classes.
Null Hypothesis: $H_0 : \mu_1 = \mu_2$
Alternative Hypothesis: $H_1 : \mu_1 \neq \mu_2$

Question 3: Paired t−test

A teacher wants to know whether a special training program improves student performance. Scores of 10 students are recorded before and after training. Use a paired t−test to determine whether the program has a significant effect.

Student	1	2	3	4	5	6	7	8	9	10
Before	45	48	50	42	47	46	49	44	43	45
After	50	52	54	46	49	50	53	47	46	48

Question 4: Chi−Square test

A survey is conducted to study whether gender is associated with preferred mode of learning. Use a chi−square test to determine whether learning preference depends on gender.

Gender	**Online**	**Offline**
Male	35	15
Female	20	30

Null Hypothesis: There is no association between gender and learning mode. Alternative Hypothesis: There is an association between gender and learning mode.

Practical 8

Data Visualization

Q1

1. Load a dataset using Python.
2. Using Matplotlib, create a line plot, bar chart, and histogram.
3. Add title, axis labels, and legend.
4. Save the plots as image files.

Q2

1. Load a dataset using Python.

2. Generate a scatter plot, box plot, and distribution plot.
3. Identify outliers, correlation trends, and distribution shape.
4. Compare two numerical variables visually.
5. Write observations for each plot.

Practical 9

Case Study–Business Data Decision System

Dataset variables:

- Advertising cost
- Sales
- Profit

Tasks

1. Represent data as a matrix.
2. Check linear dependence between variables.
3. Solve a system of equations modelling profit prediction.
4. Compute the determinant to check invertibility.
5. Compute eigenvalues and eigenvectors.
6. Interpret eigenvectors as principal business patterns.
7. Use diagonalization to simplify matrix computations.
8. Determine the rank and explain data redundancy.

Practical 10

Case Study–Employee Salary Analysis

Dataset:

- Age
- Department
- Experience
- Education level
- Salary

Tasks

1. Selection of a real-world employee salary dataset.
2. Clean and preprocess the data.

3. Perform descriptive statistical analysis and visualize salary distribution.
4. Interpret insights such as salary differences across departments and experience levels.
5. Prepare a short report.

Practical 11

Case Study−Retail Sales Analysis

Dataset:

- Product category
- Unit price
- Quantity sold
- Total sales
- Region

Tasks

1. Selection of a real-world retail sales dataset.
2. Clean missing values, remove duplicates, and format variables properly.
3. Perform statistical analysis and visualize sales trends by category and region.
4. Interpret business insights such as best−selling products and high−revenue regions.
5. Write a short report based on the analysis.

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MTS-381-OJT: On Job Training

Course type:OJT **No. of Credits: 04(P)**

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