સૌરાષ્ટ્ર યુનિવર્સિટી

એકેડેમિક વિભાગ

યુનિવર્સિટી કેમ્પસ, યુનિવર્સિટી રોડ, રાજકોટ-૩૬૦૦૦૫

ફોન નં.(૦૨૮૧)૨૫૭૮૫૦૧ એક્સટે. નં.૨૦૨, ૩૦૪ ફેક્સ નં.(૦૨૮૧)૨૫૭૬૩૪૭ ઈ-મેઈલ : academic@sauuni.ac.in

નં.એકે/વિજ્ઞાન/૨૫૦૭૧૬૭/૨૦૨૫

તા.૨૫/૦૬/૨૦૨૫

બી.એસસી.(ગણિતશાસ્ત્ર)

પરિપત્ર:-

સૌરાષ્ટ્ર યુનિવર્સિટીની વિજ્ઞાન વિદ્યાશાખા હેઠળની સ્નાતક કક્ષાના બી.એસસી.(ગણિતશાસ્ત્ર)ના અભ્યાસક્રમ ચલાવતી સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓને આથી જાણ કરવામાં આવે છે કે, અધ્યક્ષશ્રી ગણિતશાસ્ત્ર ભવન તથા વિજ્ઞાન વિદ્યાશાખાનાં ડીનશ્રી દ્વારા રજુ કરાયેલ બી.એસસી.(ગણિતશાસ્ત્ર) સેમેસ્ટર- ૦૫ નો SOP મુજબનો અભ્યાસક્રમ અધિકાર મંડળોની બહાલીની અપેક્ષાએ મંજુરી આપવા માન.કુલપતિ સાહેબને ભલામણ કરેલ જે માન.કુલપતિશ્રીએ મંજુર કરેલ છે. જેથી સંબંધિત તમામે તે મુજબ તેની અમલવારી કરવી.

(મુસદ્દો કુલસચિવશ્રીએ મંજુર કરેલ છે.)

સહી/-
(ડૉ. આર. જી. પરમાર)
I/C કુલસચિવ

બિડાણ:- ઉક્ત અભ્યાસક્રમ (સોફ્ટ કોપી)

રવાના કર્યું

25/6/25

એકેડેમિક ઓફીસર

પ્રતિ,

(૧) વિજ્ઞાન વિદ્યાશાખા હેઠળની બી.એસસી.(ગણિતશાસ્ત્ર) વિષય ચલાવતી સ્નાતક કક્ષાની સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓ તથા અનુસ્નાતક ભવનનાં અધ્યક્ષશ્રીઓ તરફ.
(૨) ગણિતશાસ્ત્ર વિષયની અભ્યાસ સમિતિનાં સર્વે સભ્યશ્રીઓ
(૩) ડીનશ્રી, વિજ્ઞાન વિદ્યાશાખા

નકલ જાણ અર્થે રવાના:-

૧. માન.કુલપતિશ્રી/કુલસચિવશ્રીના અંગત સચિવ

નકલ રવાના (યોગ્ય કાર્યવાહી અર્થે):-

૧. પરીક્ષા વિભાગ
૨. પી.જી.ટી.આર.વિભાગ
૩. જોડાણ વિભાગ

SAURASHTRA UNIVERSITY

FACULTY OF SCIENCE

Course Structure and Syllabus for Science FYUGP

B.Sc. Honours/Honours with Research in Mathematics

Based on

UGC's guidelines NEP-2020 "Curriculum and Credit Framework for Undergraduate Programmes- CCFUP" and

Education Department, Government of Gujarat's
Uniform Credit Structure for all HEIs of Gujarat State and
Implementation of the Common Curriculum and Credit Framework under the National Education Policy-2020
(No: KCG/admin/2023-24/0607/kh.1 Sachivalaya, Gandhinagardated 11/07/2023) and

Standard Operating Procedure for Implementation of NEP-2020 for the State of Gujarat- HEIs of Gujarat
(No: KCG/admin/2023-24/865/ dated 26/07/2023) and

Additional content to be added to SOP published by KCG
(No: KCG/NEP-2020/2023-24/893/ dated 28/07/2023)

General Guidelines for Implementation of **Four Year Under Graduate Programmes** for Saurashtra University (16 pages) published in August 2023
(E-mail from Academic Section Saurashtra University dated Oct 11, 2023)

Effective From June–2025 & onwards

(Submitted on 16-06-2025)

Preface

Timely revision of the curriculum to encompass new knowledge and information is a prime criterion of IQAC and a prime need for the institute educational systems affiliated with Universities. Under the NEP -2020 and UGC guidelines, a student must be offered the latest courses of varied requirement of technology with societal, environmental, and economic implications. The curriculum should offer multiple entry-exits and a choice of vast subjects to choose from to a student to facilitate his learning abilities, aptitude, and inclination.

Mathematics is a foundation subject for Physical & Chemical Sciences, Life Sciences, Statistics, Computer Science, Engineering, Commerce, Management, Agriculture, Environmental Science, Genetic engineering and hence holds the central position in the curriculum of these subjects. Looking at the rapid inventions and technological developments in the field of Mathematics and keeping in view the recommendations of UGC and NEP-2020, this syllabus has been formulated by the combined and coordinated efforts of all the faculty members of Mathematics Departments of all the Colleges affiliated to Saurashtra University.

The composition of a curriculum for a particular subject requires the following criteria to be considered:

1. Guidelines and Model curriculum provided by the UGC, State Government, and the University.
2. Regional needs and Present National and International trends in the subject.
3. Geographical parameters of the University and its demographic property.
4. Relationship with other related subjects and resources of educational needs.
5. Financial and statutory provisions of the State government.

The content of a syllabus should be such that it maintains continuity with the course content of higher secondary classes and post-graduate courses. Keeping this in mind, the current curriculum is made; and is an effort to impart fundamental knowledge of the subject needed at this level. The curriculum is designed as per the guidelines of UGC and NEP-2020 and reflects the courses' total credit, teaching hours, and question paper style. The syllabus units are well-defined, and the scope of each is given in detail. A list of REFERENCE BOOKS is provided at the end of each course. Mathematics being alogical and application based subject, sufficient emphasis is given to problem solving skills.

The following objectives have been considered while formulating the curriculum:

1. To provide an updated, feasible, and modern syllabus to the students, emphasizing knowledge and skill to build up their valuable college education and employment oriented carrier.
2. To frame the syllabus in accordance with the semester system, UGC – NEP 2020 guidelines and in consultation with all stakeholders.
3. To offer the students an array of Core, Interdisciplinary, Multidisciplinary, Skill enhancement, Ability enhancement and Value-added courses to select from and to facilitate their academic, intellectual and social grooming.

The Board of Studies for Mathematics expresses heartfelt gratitude to the Dean, Faculty of Science, Saurashtra University, for valuable guidelines and the Academic Section for much-needed cooperation. The Board wishes all the students a very bright future.

Prof. (Dr.) V J Kaneria	Chairman, BoS	Syllabus Committee, Mathematics Saurashtra University, Rajkot (Gujarat)
Prof. J. N. Chauhan	Other than Chairman, BoS	
Dr. G. V. Ghodasara	Subject Expert	
Dr. M. K. Kansagara	Subject Expert	
Dr. H. J. Kanani	Subject Expert	
Dr. G. K. Rathod	Subject Expert	

Date: 16th June 2025

Graduate Attributes:

Graduates should be able to demonstrate the acquisition of the following:

Academic Excellence: Comprehensive knowledge and coherent understanding of Mathematics and other interdisciplinary areas of study.

Practical, Professional and Procedural Knowledge: Required for carrying out professional or highly skilled work/tasks related to Mathematics, including knowledge required for undertaking self-employment initiatives and knowledge and mind-set required for entrepreneurship, improved product development, or a new mode of organization.

Critical and Analytical Reasoning/Thinking and Effective Communications: Analysis and evaluation of information to form a judgment about a subject or idea and ability to communicate the same in a structured form.

Research-Related Skills: the ability to understand basic research ethics and skills in Practicing /doing ethics in the field/ in personal research work, regardless of the funding authority or field of study.

Leadership Qualities and Teamwork Abilities: The graduates should be able to demonstrate the capability for mapping out the tasks of a team and setting direction and inspiring vision, and building a team that can help achieve the goals.

Global Citizenship: Mutual understanding with others from diverse cultures, perspectives, and backgrounds by embracing and practicing constitutional, humanistic, ethical, and moral values in life, including universal human values of truth, righteous conduct, peace, love, nonviolence, and scientific temper.

Life Long Learning: Ready to imbibe new knowledge, values, and skills with an open mind and willing to adopt change for constructive development.

Programme Outcomes (PO):

By the end of the program, the following programme outcomes are aimed to be achieved.

PO 1	**Disciplinary Knowledge:** Bachelor degree in Mathematics is the culmination of in-depth knowledge of Algebra, Calculus, Geometry, differential equations and several other branches of pure and applied mathematics. This also leads to study the related areas.
PO 2	**Communication Skills:** Ability to communicate various mathematical concepts effectively using examples and their geometrical visualization. The skills and knowledge gained in this program will lead to the proficiency in analytical reasoning which can be used for modelling and solving of real life problems.
PO 3	**Critical thinking and analytical reasoning:** The students undergoing this programme acquire ability of critical thinking and logical reasoning and capability of recognizing and distinguishing the various aspects of real life problems.
PO 4	**Problem Solving:** The Mathematical knowledge gained by the students through this programme develop an ability to analyse the problems, identify and define appropriate computing requirements for its solutions. This programme enhances students overall development
PO 5	**Research related skills:** The completing this programme develops the capability of inquiring about appropriate questions relating to the Mathematical concepts in different areas of Mathematics.
PO 6	**Information/digital Literacy:** The completion of this programme will enable the learner to use appropriate software to solve system of algebraic equations and differential equations.
PO 7	**Self – directed learning:** The student completing this program will develop an ability to work independently and to make an in-depth study of various notions of Mathematics.
PO 8	**Moral and ethical awareness/reasoning:** The student completing this program will develop an ability to identify unethical behaviour such as fabrication, falsification or misinterpretation of data and adopting objectives, unbiased and truthful actions in all aspects of life in general and Mathematical studies in general.
PO 9	**Lifelong learning:** This programme provides self-directed learning and lifelong learning skills. This programme helps the learner to think independently and develop algorithms and computational skills for solving real world problems.
PO 10	**Advanced Studies and Research:** Ability to pursue advanced studies and research in pure and applied Mathematical sciences.

Programme Specific Outcomes (PSO):

By the end of the program, the following programme specific outcomes are aimed to be achieved.

PSO 1	Student should be able to think in a critical manner and develop problem solving skills.
PSO 2	Students should be able to recall basic facts about mathematics and display knowledge of conventions such as notations, terminology etc.
PSO 3	Students are able to formulate and develop mathematical arguments in a logical manner.
PSO 4	It is to give in-depth knowledge of geometry, algebra, calculus, differential equations and several other branches of pure and applied mathematics. This also leads to study the related areas such as computer science and other allied subjects.
PSO 5	Students are motivated and prepared for research studies in mathematics and related fields.
PSO 6	Student should be able to apply their skills and knowledge in various fields of studies including, science, engineering, commerce and management etc.

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

SN	Course Category As per GoG- NEP-SOP - July 2023& additional content 28/7/23	Course Title	Credit			Hrs./ Wk.		Evaluation - Weightage CCE: SEE = 50:50				
			T	P	Total	T	P	CCE Marks		SEE Marks		Total Marks
								T	P	T	P	
1	**Major (Core) -11** (Mathematics) Based on IKS	Mathematics-11: Complex Analysis-II & Mathematics-11P: Advanced GeoGebra **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
2	**Major (Core)-12** (Mathematics)	Mathematics-12: Ring Theory & Mathematics-12P: Inner Product Space **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
3	**Major (Core)-13** (Mathematics)	Mathematics-13: Mathematical Analysis - I & Mathematics-13P: Real life Mathematical Problems **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
4	**Minor(Elective)-4**	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.2) **Any One from Basket** (As per the expertise and resources available in the college) **(4- Credit Course** including Theory & Practical components)	**2**	**2**	**4**	**2**	**4**	**25**	**25**	**50**	**-**	**100**

5	**Minor(Elective)-5**	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.2) **Any One from Basket** (As per the expertise and resources available in the college) **(4- Credit Course** including Theory & Practical components)	**2**	**2**	**4**	**2**	**4**	**25**	**25**	**50**	**-**	**100**
6	**Skill Enhancement Course-3** (SEC-3)	(As per GoG- NEP-SOP July 2023 & additional content 28/7/23 – Clause 3.3.5) Skill Based Course: SEC-5: Probability and Statistics & SEC-5P:Problems on Probability and Statistics **(2- Credit Course** including Theory & Practical components)	**1**	**1**	**2**	**1**	**2**	**-**	**25**	**25**	**-**	**50**
Total Credits and Marks (Semester-V)			14	08	**22**	14	16	**125**	**150**	**275**	**-**	**550**

Evaluation Scheme: (As per GoG- NEP-SOP July 2023 & additional content 28/7/23 – Chapter-7: Evaluation Reforms)

The evaluation process should be formulated to make a systematic evaluation of students' progress based on UGC guidelines. The evaluation must be designed with learner attributes in mind. These attributes have clear linkages to Programme Education Objectives and Outcomes. The evaluation consists of the following two components:

1. Continuous and Comprehensive Evaluation (CCE)- Formative
2. Semester End Evaluation (SEE)- Summative

CCE carries 50% of the total marks allotted to a subject and the other 50% being assigned to the SEE.

In each course, every credit carries 25 marks, of which 50% marks is assigned for CCE and rest 50% marks for SEE. The 50% marks assigned to the CCE is distributed between the continuous classroom evaluation and mid-term evaluation. The pattern may be as follows:

SN	Evaluation	T-3+P-1 = Total 4 credit subjects (Marks)	T-2+P-2 = Total 4 credit subjects (Marks)	T-1=P-1=Total 2 credit subjects (Marks)
1	CCE (50%)			
	Classroom & Mid-Term Evaluation	T-25+P-25	T-25+P-25	25
2	SEE (50%)	50	50	25
	Total	**100**	**100**	**50**

Continuous and Comprehensive Evaluation (CCE)

Subject–wise CCE will be undertaken by the concerned faculty member. The mode of evaluation will be decided by the faculty member concerned with the subject. Normally CCE consists of class participation, case analysis and presentation, assignment, tutorials, slip tests (announced/ surprised), quizzes, attendance etc. or any combination of these. The students are expected to submit their answer scripts/ reports of internal evaluation within the stipulated time. Failure to do so may result in the script not being valued. Another part of CCE consists of mid-term written evaluation, which is compulsory for all students. It can be done in a scheduled manner. The duration of the mid-term evaluation shall be one hour.

Semester End Evaluation (SEE)

The SEE carries 50% of the marks assigned to a course. SEE shall be of 2 hours for3/ 4 credit course and 2 hours in case of 1/2 credit courses. The controller of the examination will conduct these examinations. Paper setting and evaluation will be done by the external examiners to an extent of 50% of the evaluation process. This examination shall be conducted as per a schedule which shall be notified in advance.

The backlog exam will be conducted twice a year just after the result declared of the semester evaluation. Students shall have a second chance to clear their backlog and avoid the burden to carry forward the backlog with the next semester exam.

Appearance in all the evaluations is mandatory and no exemption can be granted except in the following cases:

1. In case of inability to attend the exam due to reasons considered genuine by the controller of examination in consultation with the Director/Board.

2. In case of medical emergency, a certificate from the registered medical practitioner must be produced before the commencement of exams. The evaluation board will then take final decision on the recommendation for exemption.

Eligibility Criteria to appear in SEE

To be able to appear for the SEE, a student must comply with the following conditions:

1. Should have at least 75% of attendance in all the courses put together.

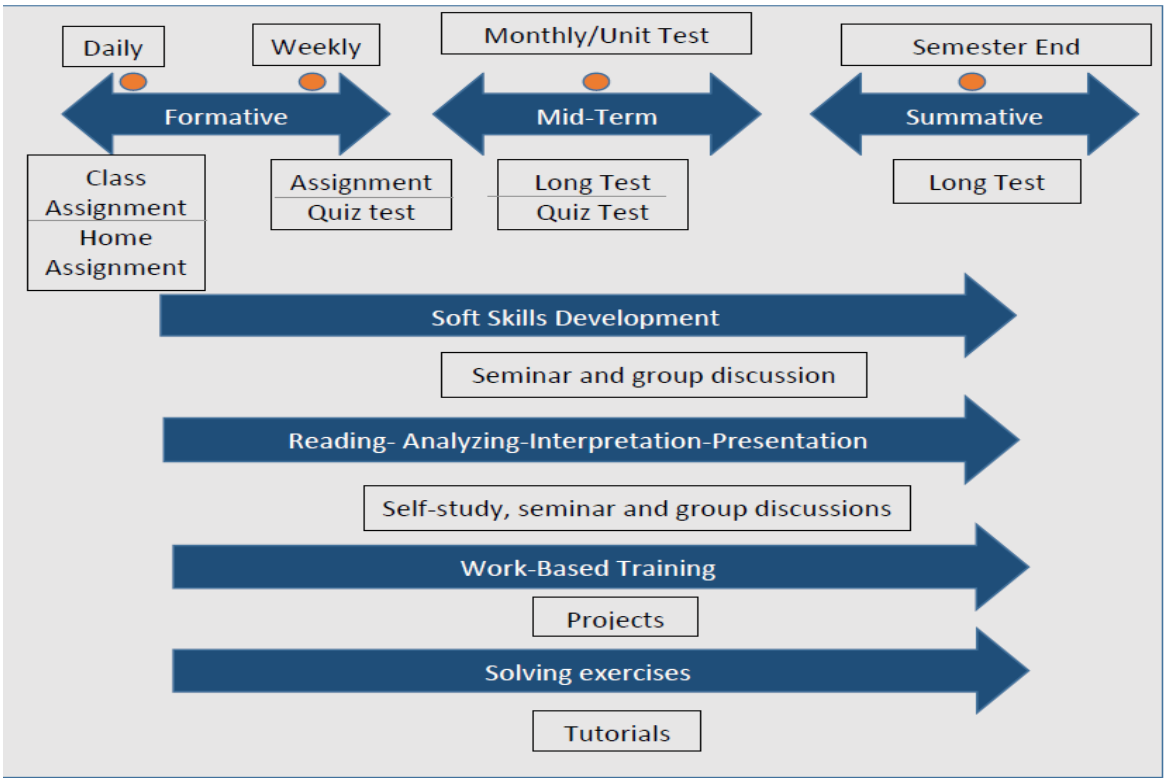
2. Should have at least 70% of attendance in each course/subject.

3. Should not have any disciplinary proceedings pending against him/her.

4. Should have no pending due.

Continuum of Evaluation

Evaluation must be continuous which may include both formative and summative components in a timely manner for continuous feedback as follow:



Mode of Evaluation

A wide range of modes of evaluation for evaluating students is available for the teachers/ institutions to use. A suitable compendium of such a mode needs to be carefully chosen for a particular program depending on its nature, objectives, and available resources. The mode of evaluation can be as below:

Written Mode	Oral Mode	Practical Mode	Integrated Mode
Semester Exam Class Test Open book exam/test Open note exam/test Self-test/Online test Essay/Article writing Quizzes/Objective test Class assignment Home assignment Reports writing Research/Dissertation Class Studies	Viva/Oral exam Group Discussion Role Play Authentic Problem Solving Quiz Interview	Lab work Computer simulation/virtual labs Craft work Co-curricular work	Paper presentation/Seminar Field Assignment Poster Presentation

Written Mode		
Evaluation Type	**Nature**	**Objective**
Semester Exam	Traditionally essay type with objective/short answer questions to evaluate Lower Ordered Thinking (LOT) OBE skills.	For depth and planned preparation
Class test	Traditionally essay type	Fixed date forces students to learn
Open book test	Allowed choice of reference book	Measures what students can do with resources, less stress on memory
Open note test	To get used to the system	Encourage good note taking
Self-test	For subjective and objective items	Mastery learning occurs with proper feedback
Article/essay writing	Individual long written assignment	Individual expression and creativity
Quizzes/Objective test	Short duration structured test	Excellent validity as greater syllabus coverage
Class assignment	With defined time	Student's performance to make decision
Home assignment	With undefined time	Reinforce learning and facilitate mastery of specific skills
Reports Writing	On activities performed or event observed	Develop a key transferable skill
Research/Dissertation	Detailed research-based report	To judge creativity and research skills

Case Studies	Analyse a given case (real or fictional)	To assess thinking, value, and attitude
Oral Mode		
Evaluation Type	**Nature**	**Objective**
Viva/Oral exam	Individually or in small group	Practical experience towards job interview situation
Group discussion	Small group of 2-5 members work on a joint task	Encourage teamwork
Role Play	Small group of 2-5 members work on a joint task	Develop personality
Authenticate problem solving	Small group of 2-5 members work on a joint task	Communication of ideas
Quiz	Small group of 2-5 members work on a joint task	Assess memory power
Interview	Individually	Judge the personal confidence level

Practical Mode		
Evaluation Type	**Nature**	**Objective**
Lab work	Component of working with one's hand	Keep the students on the task
Computer simulation/virtual labs	Component of working with one's hand	To understand the practical exposure
Craft work	Component of working with one's hand	Encourage application of concepts learnt
Co-curricular work	Component of working with one's hand	For immediate feedback

Integrated Mode		
Evaluation Type	**Nature**	**Objective**
Paper presentation/Seminar	Group or individual work	Learn from others presentation
Field Assignment	Field visit with report	Develop observation and recording skills
Poster presentation	Group or individual work	Develop research, creativity, and discussion skills

Models of Evaluation

Based on the types of evaluation, various models of evaluation implementation are suggested for theory, practical, self-study and work-based learning. The focus of these models is to encourage the students to improve on skills and performance.

Evaluation Norms & Question Paper Pattern for Theory & Practical Courses:
Please refer General Guidelines for Implementation of Four Year Under Graduate Programmes for Saurashtra University (16 pages) published in August 2023.

Model for Theory Courses- Theory-3+Practical-1 = 4 Credit Course	
CCE-50% (50 Marks) & SEE-50% (50 Marks)	
Exam Pattern	**Marks**
Class Test (Average of **TWO** tests)	**T-25+P-25**
Quiz (Average of **TWO** quizzes)	
Home Assignment	
Active Learning- PBL/CSBL/Seminar/Flipped Class Room etc..OBE tools.	
Class Assignment	
Attendance	
Continuous and Comprehensive Evaluation	
Semester-End Evaluation	**T-50**

Model for Practical Courses-1 Credit Course	
CCE-100% (25 Marks)	
Exam Pattern	**Marks**
Lab work assessment	10
Viva voce/Lab quiz	10
Attendance	05
Continuous and Comprehensive Evaluation	**25**

Model for Theory Courses- Theory – 2 + Practical - 2 = 4 Credit Course	
CCE-50% (50 Marks) & SEE-50% (50 Marks)	
Exam Pattern	**Marks**
Practical Examination	**25**
Continuous and Comprehensive Evaluation	**Practical Internal 25**
Class Test (Average of **TWO** tests)	
Quiz (Average of **TWO** quizzes)	
Home Assignment	
Active Learning- PBL/CSBL/Seminar/Flipped Class Room etc..OBE tools.	
Class Assignment/Lab Assignment	
Attendance	
Semester-End Evaluation	**T-50**

Model for Practical Courses-2 Credit Course	
CCE-100% (25 Marks)	
Exam Pattern	**Marks**
Lab work assessment	10
Viva voce/Lab quiz	10
Attendance	05
Continuous and Comprehensive Evaluation	**25**

Model for Skill Enhancement Course - Skill based Practical Course **2 Credit (1-Theory+1-Practical=2) Course**	
CCE-50% (25 Marks) SEE-50% (25 Marks)	
Exam Pattern	**Marks**
Lab work assessment or Project based Assessment	10
Viva voce/Lab quiz	10
Attendance& Performance	05
Continuous and Comprehensive Evaluation	**25**
Semester-End Evaluation	**25**

Theory Question Paper Pattern

Semester End Examination (SEE)
Major – 4 Credit Course (Theory)

Instructions:

- All Units/ Module carry equal weightage of 10 Marks each.
- There must be One Question from each Unit/ Module.
- Time duration: 2 Hours.
- Marks: 50.

The Theory Question Paper Skeleton is as follows.

Question 1 (Unit/Module 1)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)
Question 2(Unit/Module 2)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)
Question 3(Unit/Module 3)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)
Question 4(Unit/Module 4)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)
Question 5(Unit/Module 5)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)

Theory Question Paper Pattern

Semester End Examination (SEE)
Minor – 4 (2+2) Credit Course (Theory)

Instructions:

- All Units/ Module carry equal weightage of 10 Marks each.
- There must be One Question from each Unit/ Module.
- Time duration: 2 Hours.
- Marks: 50.

The Theory Question Paper Skeleton is as follows.

Question 1 (Unit/Module 1)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)
Question 2 (Unit/Module 2)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)
Question 3 (Unit/Module 3)		Marks
A		(10/7/6/5)
B		(0/3/4/5)
OR		
A		(10/7/6/5)
B		(0/3/4/5)
Question 4 (From any Unit/Module 1/2/3)		Marks
A		(10)
B		(10)
OR		
A		(10)
B		(10)

Practical Question Paper Pattern
Semester End Examination (SEE)
Major/Minor/MDC/IDC - 4 Credit Course (Practical/Performance)

Instructions:

- Certified journal is must and minimum requirement to appearing for semester end practical examination.
- Should have at least 75% attendance in practical sessions during the semester.
- Time duration: **2** Hours.

One Practical/Performance of 25 Marks (Viva – 10 Marks & Practical – 15 Marks)

Exam Pattern	**Marks**
Attempt any 3 out of 5 problems. (*Each problem carry 05 Marks; Each problem may be split into sub-problem(s)/question(s), if required.)	15
Viva-voce and Journal	10
CCE	**25**

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Major (Core)-11 (Based on IKS)**
Title of the Course	**Mathematics-11: Complex Analysis-II**
Course Credit	**03**
Teaching Hours per Semester	**45**
Total Marks	**CCE-25 + SEE-50**

Course Objectives

1) To develop an understanding of complex integration, contours, and the fundamental properties of line integrals in the complex plane.
2) To explore and apply key theorems in complex analysis such as Cauchy's Integral Theorem and Formula, Liouville's Theorem, and the Maximum Modulus Theorem.
3) To study the analytic structure of complex functions through series expansions, including Taylor and Laurent series, and their role in classification of singularities.
4) To enable learners to compute residues and apply the Residue Theorem in evaluating real and complex integrals.
5) To introduce the application of Indian Knowledge Systems (IKS), such as early contributions to algebra and complex numbers by Indian mathematicians like Bhaskara II and Madhava, within the context of historical mathematical evolution.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Recall and explain key concepts in complex integration, analyticity, and convergence of complex sequences.
2) Interpret standard results such as Cauchy's theorem, Cauchy's Integral Formula, and Liouville's Theorem with appropriate examples.
3) Apply the Residue Theorem to evaluate complex and improper real integrals, including definite integrals involving trigonometric and exponential functions.
4) Analyze singularities and determine the type (removable, pole, essential) using Laurent series and the classification of zeros and poles.
5) Evaluate and construct Taylor and Laurent series expansions for complex functions and use them to determine function behavior near singular points.
6) Design contour integrals and select appropriate methods for integration using advanced theorems, thereby solving complex real-world and theoretical problems.
7) Appreciate the connection between historical Indian contributions and modern mathematical methods.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		Yes	Minor		No
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					Yes

Unit No.	Topics	Hours	Marks
I	• **Complex Integration:** Definition of complex integral along a curve, Properties of complex integration, Path and line integrals. • **Contours:** Parametric representation of contours, Smooth and piecewise smooth curves, Simple closed curves. • **Definite Integrals:** Evaluation of definite integrals using parametrization, Examples involving circular and rectilinear paths. • **Cauchy-Goursat Theorem:** Statement for simply connected domains, Conditions under which the integral around a closed contour is zero, Illustrative examples.	9	10
II	• **Cauchy's Integral Formula:** Formula for function and its derivatives, Applications and examples, Morera's Theorem, Converse of Cauchy's theorem, Proof and applications in determining analyticity. • **Higher-order Derivatives of Analytic:** Functions, Derivation from Cauchy's Integral Formula, Examples involving polynomial and rational functions • **Properties of Analytic Functions and Results based on it** • **Cauchy's Inequality:** Bound on the magnitude of derivatives of analytic functions, Examples involving estimation problems.	9	10
III	• **Liouville's Theorem:** Bounded entire functions are constant, Applications to non-existence of certain functions. • **Fundamental Theorem of Algebra:** Every non-constant polynomial has at least one complex root, Proof using Liouville's Theorem, Application to polynomial factorization.	9	10

	• **Maximum Modulus:** Theorem, Statement and geometric interpretation, Behavior of modulus on boundary and interior of domain, Application in uniqueness problems. • **Complex Sequences:** Convergence and limit of a complex sequence, Comparison with real sequences		
IV	• **Complex Series and Power Series:** Convergence of complex series, Radius and region of convergence, Examples with geometric and exponential series • **Expansion Using Taylor's Series:** Conditions for expansion, Finding Taylor series centered at a point, Examples including e^z, sin z, cos z. • **Laurent's Series:** Expansion around isolated singularities, Principal and analytic parts, Classification of singularities using Laurent expansion. • **Singular Points and Isolated Singularities:** Classification: removable, pole, essential, Techniques for identification. • **Zeros, Poles, and Residues of Complex Functions:** Order of zero and pole, Residue at a pole: simple and higher order. • **Laurent Series and Ramanujan's Infinite Series** • **Ramanujan's Theta Function connected with Complex Analysis**	9	10
V	• **Cauchy's Residue Theorem:** Statement and proof, Application to contour integration. • **Evaluation of Improper Real Integrals** using Residue Theorem, Techniques for rational functions over the real axis, Examples including integrals with trigonometric and exponential terms. • **Evaluation of Definite Integrals of Trigonometric Functions:** Use of complex exponentials, Integrals over $[0, 2\pi]$ and infinite intervals.	9	10

Text book:

1) James Ward Brown and Ruel V. Churchill, (2023 -Latest Reprint), ***Complex Variables and Applications,*** 9th edition, McGraw Hill Higher Education l, New Delhi, India

Reference books:

1) Shanti Narayan and Dr. P. K. Mittal, (2020), ***Theory of Functions of a Complex variable, 5th edition,*** S. Chand Publications, New Delhi, India.
2) Ahlfors, Lars V., ***Complex Analysis***, 4th Edition, 2019, McGraw-Hill Education, New York, USA.
3) Shanti Narayan, and Mittal, P. K., ***Theory of Functions of a Complex Variable***, 5th Edition, 2019, S. Chand Publishing, New Delhi.
4) Dennis G. Zill and Patrick D. Shanahan, (2019), ***Complex Analysis- A First Course with Applications,*** 3rd edition, Jones and Bartlett Publishers, Inc., Sudbury, Massachusetts, USA
5) Lang, Serge, ***Complex Analysis***, 4th Edition, 2022, Springer, New York, USA.
6) Bruce C. Berndt, ***Ramanujan's Notebooks Part***, Springer (These include deep analysis of Ramanujan's results)
7) Tom M. Apostol, ***Modular Functions and Dirichlet Series in Number Theory***, Springer.

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Major (Core)-11 Practical**
Title of the Course	**Mathematics-11P: Advanced GeoGebra**
Course Credit	**01**
Teaching Hours per Semester	**30**
Total Marks	**CCE-25**

Course Objectives

By the end of this course, learners will be able to:

1) Reinforce prior GeoGebra skills and extend them to advanced 2-D, 3-D, and CAS features.
2) Enable visual investigation of calculus concepts and elementary complex-analysis plots.
3) Develop dynamic models for vector algebra, linear transformations and polar curves.
4) Produce statistically meaningful charts and simulations directly in GeoGebra.
5) Encourage creative, student-designed mini-projects integrating multiple mathematical ideas.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Recall advanced toolbar icons, view switches and dynamic-color options.
2) Explain how sliders and conditional visibility control interactive diagrams.
3) Apply GeoGebra to visualize limits, derivatives and integrals of a chosen function.
4) Analyze eigen-vectors by observing invariant directions under a matrix transformation.
5) Evaluate goodness-of-fit between simulated and theoretical probability distributions.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		Yes	Minor		No
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No

8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?	No

Pr.No.	Practical
1	**Revision of GeoGebra Interface & Advanced Tools** • Refresh key shortcuts, layers, CAS/3D views. • Enable advanced settings (dynamic colors, conditional visibility) for richer visualizations.
2	**2D Geometry & Constructions** • Construct conics, special triangles and their loci. • Demonstrate classical theorems (e.g., Nine-point circle) via dynamic manipulation.
3	**Calculus, Complex Plane & Analysis** • Animate limits, derivatives and Riemann-sum approximations. • Plot complex numbers as points/vectors in the Argand plane and visualize simple Möbius transforms.
4	**Vectors & Linear Transformations** • Model vectors, dot/cross products and projections. • Demonstrate matrix actions (rotation, shear, eigen-directions) on a grid or image.
5	**Trigonometry & Polar Geometry** • Generate unit-circle animations of sine/cosine. • Create polar curves (cardioid, spiral) and link to parametric form.
6	**3-Dimensional Geometry** • Build basic solids (cube, sphere, pyramid) and measure volumes/surface areas. • Slice a solid of revolution and visualize cross-sections.
7	**Statistics & Probability Visuals** • Use GeoGebra spreadsheet to plot histograms, box-plots. • To use GeoGebra to create and interpret visual representations of data: histograms, box plots, and bar charts
8	**Mini-Project & Animation** • Combine sliders, input boxes and scripting to create an interactive exploration (e.g., projectile path, convergence of a series, complex-root locus). • Submit worksheet file plus short reflection.

Text Books:

1) D. P. Acharya and T. K. Ray, (2023), Practical GeoGebra: A Step-by-Step Approach, Narosa Publishing House, NEW DELHI (Delhi), INDIA
2) Dr Jitendra Singh, Dr Pawan Chanchal, Dr. Purushottam Jharotia (2024), Interactive Mathematics Practicals with GeoGebra 2nd Edition, Publisher: Dr Jitendra Singh.
3) Hohenwarter, Markus, and Judith Preiner. Dynamic Mathematics with GeoGebra, Springer, Eastern Economy Edition, 2024.
4) Balacheff, Nicolas, and Zsolt Lavicza. Emergent Practice and Evaluation of GeoGebra, Springer, 1st edition, 2020
5) Mrs. G. Rama, Introduction to GeoGebra(2024), San International Scientific Publications, India

Reference Books:

Karl Aubrey et al.(2019), ***GeoGebra for All: Unleashing Dynamic Mathematics for Everyone***, Tarquin Publications, 1st edition.

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Major (Core)-12**
Title of the Course	**Mathematics-12: Ring Theory**
Course Credit	**03**
Teaching Hours per Semester	**45**
Total Marks	**CCE-25 + SEE-50**

Course Objectives

By the end of this course, learners will be able to:

1) Introduce students to the foundational concepts of rings, subrings, fields, and integral domains through definitions and illustrative examples.
2) Develop a conceptual understanding of polynomial rings and associated operations such as addition, multiplication, and division.
3) Foster the ability to apply algebraic theorems such as the Factor Theorem, Remainder Theorem, and Unique Factorization Theorem to polynomial rings.
4) Enable learners to understand and analyse the structure-preserving maps between rings through ring homomorphisms and the concept of ideals.
5) Equip students with algorithmic tools such as the Division Algorithm and Euclidean Algorithm for computing G.C.D. of polynomials and understanding reducibility.

Course Outcomes– COs

Upon completion of this course, the learner will be able to

1) Define and identify basic structures such as rings, subrings, fields, and integral domains with examples.
2) Explain the properties of polynomial rings and the role of leading coefficients, degrees, and zero divisors.
3) Apply the Factor and Remainder Theorems to determine roots and simplify polynomials over various fields.
4) Analyse the structure and significance of ideals, principal ideals, and ring homomorphisms through algebraic mappings and properties.
5) Evaluate the reducibility or irreducibility of polynomials using appropriate criteria and determine their factorization.
6) Construct algorithms to compute the G.C.D. of polynomials and apply the Euclidean algorithm for problem-solving in polynomial rings.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?			Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?			Yes
3	Major	Yes	Minor	No

	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

Unit No.	Topics	Hours	Marks
I	• Rings and Their Properties • Definition and examples of rings (commutative and non-commutative) • Subrings, fields, and zero divisors	**9**	**10**
II	• Integral domains and their properties • Characteristics of a ring and examples • Cancellation law in integral domains • Fields: Definition and Examples	**9**	**10**
III	• Polynomial rings over a field and their structure • Operations on polynomials: sum, product, division • Degree of a polynomial, leading coefficient, and zeroes • Factor Theorem and Remainder Theorem	**9**	**10**
IV	• Ring homomorphisms and their applications • Definition and properties of ideals • Principal ideals and their significance	**9**	**10**
V	• Reducible and irreducible polynomials • Unique Factorization Theorem for polynomials • Division Algorithm for polynomials • Concept of G.C.D. (Greatest Common Divisor) of polynomials • Euclidean algorithm for polynomials	**9**	**10**

TEXTBOOKS:

1. I. H. Sheth, 3rd edition, (2009), ***Abstract Algebra,*** Prentice/Hall of India Private Limited, New Delhi(Unit - 1 to5)
2. I. N. Herstein, (1975), ***Topics in Algebra,*** John Wiley & Sons, New York

REFERENCE BOOKS:

1. Thomas W. Judson, (2019), ***Abstract Algebra Theory and Applications***, Orthogonal Publishing L3C, Columbia, Missouri, USA
2. Joseph A. Gallian, (2021) Fourth Edition (10th edition), ***Contemporary Abstract Algebra***, Narosa Publishing House, New Delhi.
3. Marlow Anderson & Todd Fel, (2015), ***A first course in Abstract Algebra*** (Rings, Groups & fields), Chrpman & Halilereivy, 3rd edition.
4. Fraleigh J.B., (2014), ***A First Course in Abstract Algebra***, (7th edition), Narosa Publishing, New Delhi, India.

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Major (Core)-12 Practical**
Title of the Course	**Mathematics-12P: Inner Product Space**
Course Credit	**01**
Teaching Hours per Semester	**30**
Total Marks	**CCE-25**

Course Objectives

By the end of this course, learners will be able to:

1) To introduce students to the computational aspects of inner product spaces through practical implementation.
2) To develop the ability to verify fundamental properties of norms, distances, and orthogonality in Euclidean spaces.
3) To enhance conceptual understanding of inequalities (like Cauchy-Schwarz) via numerical and graphical methods.
4) To provide hands-on experience in orthonormalization techniques, including Gram-Schmidt processes.
5) To promote the use of programming to analyze and visualize linear algebraic concepts in R^2 and R^3.

Course Outcomes– COs:

Upon completion of this course, the learner will be able to

1) Recall the definitions of inner product, norm, distance, and orthogonality in vector spaces.
2) Describe and explain the significance of properties such as symmetry, non-negativity, and the triangle inequality.
3) Apply inner product formulas to calculate norms and distances.
4) Analyze the conditions under which vectors are orthogonal or form orthonormal sets.
5) Apply Gram-Schmidt orthogonalization to construct orthonormal basis.

Pr. No.	Practical
1	Introduction to Inner Product Spaces; Definition of Inner product and Inner product

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		Yes	Minor		No
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

	space, Properties of Inner product space.
2	Basic examples to verify inner product space.
3	Norm Induced by Inner Product.
4	Orthogonality and Pythagorean Theorem
5	Cauchy-Schwarz Inequality and Triangle Inequality
6	Parallelogram Law
7	Inner Product in Function Spaces
8	Orthonormal Sets
9	Orthogonal Projection
10	Gram-Schmidt Orthogonalization Process

Text Books:

1) Friedberg, Stephen H., Arnold J. Insel, and Lawrence E. Spence.(2015) ***Linear Algebra.*** PHI Learning Private Limited, 4th Edition.
2) Kumaresan, S. Linear Algebra(2017): ***A Geometric Approach.*** PHI Learning Private Limited , New Delhi (Delhi), India
3) Krishnamurthy, Mainra, and Arora.(2019), ***An Introduction to Linear Algebra***. Affiliated East-West Press PVT LTD, New Delhi

Reference Books:

1) Anton, Howard, Chris Rorres, and Albert Herr(2013). ***Elementary Linear Algebra: Applications*** Version. Wiley Eastern Limited, 11th edition,
2) Shilov, Georgi E. ***Linear Algebra(2012)***. Dover Publications, 2nd edition.
3) Sharma, J. N., and A. K. Vasishtha(2018)***. Matrix Theory***. Krishna Prakashan Media.
4) Gelfand, Israel M., and Alexander Shen(2005). ***Linear Algebra***. Springer.

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Major (Core)-13**
Title of the Course	**Mathematics-13: Mathematical Analysis – I**
Course Credit	**03**
Teaching Hours per Semester	**45**
Total Marks	**CCE-25 + SEE-50**

Course Objectives

By the end of this course, learners will be able to:

1) To develop a foundational understanding of set theory and its applications in mathematical analysis, including operations on sets, countability, and functions.
2) To introduce the concept of metric spaces and provide a framework for discussing convergence, continuity, and topological properties using various metrics.
3) To explore the structure of open and closed sets in metric spaces and understand concepts such as neighbourhoods, limit points, and interior points.
4) To analyze topological properties of subsets in metric spaces, including boundary, derived, dense, and nowhere dense sets.
5) To study continuous functions on metric spaces and special constructs such as the Cantor set, and understand their significance in real analysis.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Recall and define basic concepts such as countable sets, metric spaces, neighbourhoods, open and closed sets.
2) Explain the properties of different types of metric spaces (e.g., discrete, usual), continuous functions, and image/inverse image sets.
3) Apply the definitions and properties of metric spaces, open and closed sets, and continuous functions to solve related problems.
4) Analyze the structure of sets in metric spaces to determine whether they are open, closed, dense, or nowhere dense.
5) Evaluate different functions and subsets with respect to continuity and topological properties using various metric space examples.
6) Construct and represent real numbers using the Cantor set and develop new examples to illustrate derived sets and closure. Construct examples or counterexamples of sets that satisfy given topological properties using theorems like Nested Interval and Bolzano-Weierstrass.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		Yes	Minor		Yes
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

Unit No.	Topics	Hours	Marks
1	• Bounded set, Real valued function, one-one, onto function. • Definition of Similar sets. • Problems based on similarity of sets. • Countability of a set, Properties of Countability. • Problems based on Countable set.	**9**	**10**
2	• Metric Space – definition, results and properties. • Usual Metric Space and Discrete Metric Space. • Problems based on Discrete Metric Space. • Problems based on Metric Derived from other Metric. • Some important results based on Discrete Metric Space.	**9**	**10**
3	• Neighbourhood, Interior and exterior point, Open set. • Limit point of a set, Closed set, Closure of a set, Boundary point of a set, Derived set, Dense set, Nowhere Dense set. • Examples based on the above types of points and sets.	**9**	**10**
4	• Hausdorff Principle • Hausdorffness of a Metric Space • Subspace of a Metric Space • Open Sets and Closed Sets in Subspace of a Metric Space. • Results based on Housedorffness and Subspace of a Metric Space.	**9**	**10**
5	• Continuity in metric space • Characterization of continuity in terms of open and closed sets. • Characterization of continuity in terms of sequence	**9**	**10**

	• Definition of the Cantor set. • Ternary Expansion of a Number and belongness of a number in the Cantor set.		

TEXTBOOKS: -

1. J. N. Sharma and A. R. Vashishtha, (2017), ***Mathematical Analysis - I***, Krishna Prakashan Mandir, MEERUT(U.P.)

REFERENCE BOOKS: -

1. S. C. Malik & Savita Arora, (2017), ***Mathematical Analysis***, New Age Int. Pvt. Ltd.
2. Shantinarayana, (2005), ***A first course of Mathematical Analysis***, S. Chand & sons.
3. Tom.M.Apostol, (1985), ***Mathematical Analysis,*** Narosa Publishing House.
4. R. R. Goldberg, (2019), ***Methods of Real Analysis,*** Oxford & IBH Publishing Co. Pvt. Ltd.
   H. L. Royden, (2015), ***Real Analysis,*** Prentice Hall of India Pvt Ltd. New Delhi

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Major (Core)-13 Practical**
Title of the Course	**Mathematics-13P: Real Life Mathematical Problems**
Course Credit	**01**
Teaching Hours per Semester	**30**
Total Marks	**CCE-25**

Course Objectives

By the end of this course, learners will be able to:

1) Link classroom mathematics with authentic real-world applications across science, engineering, and finance.
2) Develop modelling skills that translate verbal scenarios into mathematical formulations.
3) Equip students with analytical techniques (limits, calculus, geometry) for decision-making contexts.
4) Encourage critical thinking through open-ended problem selection and solution validation.
5) Foster teamwork, communication, and presentation skills via group investigations and reports.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Recall core formulas for compound interest, derivative rules, and area/volume integrals.
2) Explain how trigonometric functions and the Mean Value Theorem relate to physical measurements.
3) Apply calculus and geometry to compute quantitative results for navigation or engineering tasks.
4) Analyze data from a real system and fit an appropriate mathematical model. (K4)
5) Evaluate competing models by comparing predictive accuracy and underlying assumptions.
6) Create and present a comprehensive solution report for a self-selected real-life mathematical problem.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		Yes	Minor		No
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	Yes
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

Pr.No.	Practical
1	Limits and Sequences in Population and Finance.
2	Applications of Trigonometry in Engineering and Architecture.
3	Geometry in Navigation and Satellite Systems.
4	Differentiation in Motion and Rate of Change.
5	Integration in Area, Volume and Economics.
6	Mean Value Theorem in Transportation and Quality Control.
7	Problems based on Geometry
8	Mathematical Puzzle: Hidden Mathematics in Real-world Scenario
9	Identify, Formulate, Analyze and Solve Real Life Mathematical Problems by Students.

TEXTBOOKS:

1) Frank R. Giordano, Maurice D. Weir & William P. Fox, (2024), ***A First Course in Mathematical Modeling,*** 6th Ed., Cengage Learning India, NEW DELHI (Delhi), INDIA

REFERENCE BOOKS:

1) Robert L. Borchers & David B. Hanson, (2022), ***Applied Calculus of Variations for Engineers,*** 3rd Ed., Springer Nature, GURUGRAM (Haryana), INDIA
2) J. David Logan, (2023), ***Applied Mathematics,*** 5th Ed., Wiley India, NEW DELHI (Delhi), INDIA

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Minor (Elective) - 4**
Title of the Course	**Mathematics - 4: Programming in C**
Course Credit	**02**
Teaching Hours per Semester	**30**
Total Marks	**CCE-25 + SEE-50**

Course Objectives

By the end of this course, learners will be able to:

1) To introduce students to the basics of C programming, including the history, syntax, and structure of C language programs.
2) To enable students to use basic data types, operators, and control structures, such as decision-making and loop statements, to write simple programs.
3) To develop the ability to write modular programs using user-defined functions and utilize control flow effectively for logic building.
4) To familiarize students with macro expansion and simple use of the C preprocessor, enabling efficient and organized code writing.
5) To provide hands-on experience in array handling (1D and 2D) for simple computational tasks using basic input/output functions and logic construction.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Identify and recall the syntax, keywords, operators, and data types used in the C programming language.
2) Describe the behavior and function of control statements and loops in C programming with examples.
3) Apply C language constructs such as if, for, while, and functions to solve simple real-life mathematical problems programmatically.
4) Analyze program logic to find errors or optimize flow using proper loop structures and conditional statements.
5) Evaluate and debug small programs using arrays and macros to ensure they meet functional requirements.
6) Design and implement modular programs in C using user-defined functions and arrays to perform basic scientific and mathematical computations.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		No	Minor		Yes
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	Yes
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

Unit No.	Topics	Hours	Marks
I	History of C, C character set, Constants, Variables, Keywords, Type Declaration, Type Conversion, Hierarchy of operators, printf & scanf functions, if statement, if-else statements, Nested if-else, Logical operators, Conditional operators. Simple programs relevant to this unit.	**9**	**15**
II	While loop, for loop, do while loop, break statement, Continue statement goto statement, Introduction to User Defined Functions. **[Omit:- switch case statement, Pointers and Recursion]** Data types in C Integers: long and short types, signed and unsigned characters, Signed and unsigned float and doubles. Simple programs relevant to this unit.	**12**	**20**
III	C processors, meaning , Only Macro Expansion, Macros with Arguments, **[OMIT:- File inclusion and various directives Conditional Compilation #if and #elseif Directives, Miscellaneous Directives #undef Directive #pragma Directive]** Arrays, meaning: one dimensional and two dimensional, only initialization and use in simple programs. **[OMIT:- no pointers and no three dimensional array, Arrays and functions]** Simple programs relevant to this unit.	**9**	**15**

TEXTBOOKS: -

1. Yashvant Kanetker, (2024), LET US C, 20th Edition, BPB Publications, New Delhi.
2. E. Balagurusamy, (2019), Programming in ANSI C, McGrew Hill Education, 8th Edition.

REFERENCE BOOKS: -

1. Brian W. Karnighan and Dennis M. Ritchie, (1988), The ANSI C Programming Language, 2nd edition, Prentice Hall, New York, USA.
2. V. Rajaraman, (1921), Computer Programming in C, 2nd edition, PHI Learning Pvt. Ltd., New Delhi, India.

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Semester V

Course Category	**Minor (Core)-4 Practical**
Title of the Course	**Mathematics 4: Practicals on C Programming**
Course Credit	**02**
Teaching Hours per Semester	**04**
Total Marks	**CCE-25**

Course Objectives

By the end of this course, learners will be able to:

1) To enable students to implement mathematical logic through C programming by writing and executing simple and relevant programs.
2) To develop fundamental programming skills such as control flow, iteration, conditionals, and basic I/O operations through structured exercises.
3) To practice solving real-life mathematical problems using code, such as finding primes, solving equations, and working with sequences and matrices.
4) To introduce algorithmic thinking through basic problems, such as checking palindromes, Armstrong numbers, and generating progressions.
5) To familiarize students with elementary matrix operations and number-theoretic functions via programmatic implementation in C.

Course Outcomes

Upon completion of this course, the learner will be able to

1. Recall and apply syntax and logic to write C programs that perform basic number operations like reversing digits and finding palindromes.
2. Understand and explain control structures such as loops and conditionals used in programs for prime numbers or arithmetic sequences.
3. Apply C programming skills to construct and execute programs involving arithmetic and geometric progressions and combinatorial functions.
4. Analyze user input and program output to debug and enhance the logic of matrix operations and number-theoretic functions.
5. Evaluate the efficiency of different approaches to solving problems like prime generation or matrix multiplication in terms of logic clarity and correctness.
6. Design and implement new programs combining multiple concepts (loops, conditionals, arrays) to solve mathematical problems like nCr, palindrome detection, or Armstrong numbers.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		No	Minor		Yes
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	Yes
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

PN	Practical
1	To find compound interest for given years.
2	To solve the quadratic equation.
3	To reverse given number.
4	To verify given number is palindrome or not.
5	To find sum of the digits of given number.
6	To print Armstrong numbers.
7	To find number of odd number and even numbers between given range.
8	To find prime number between two numbers,
9	To generate arithmetic and geometric progressions.
10	To find ${}^{n}P_{r}$ and ${}^{n}C_{r}$ for given numbers n and r.

TEXTBOOKS: -

1. Yashvant Kanetker, (2024), LET US C, 20th Edition, BPB Publications, New Delhi, India.
2. E. Balagurusamy, (2019), Programming in ANSI C, McGrew Hill Education, 8th Edition.

REFERENCE BOOKS: -

1. Brian W. Karnighan and Dennis M. Ritchie, (1988), The ANSI C Programming Language, 2nd edition, Prentice Hall, New York, USA.
2. V. Rajaraman, (1921), Computer Programming in C, 2nd edition, PHI Learning Pvt. Ltd., New Delhi, India.

B.Sc. Honours/ Honours with Research in Mathematics

(NCrF Level- 4.5 Diploma in Mathematics)

Semester V

Course Category	**Minor (Elective)-5**
Title of the Course	**Mathematics-5: Numerical Analysis-II**
Course Credit	**02**
Teaching Hours per Semester	**30**
Total Marks	**CCE-25 + SEE-50**

Course Objectives

By the end of this course, learners will be able to:

1) To develop a strong conceptual understanding of interpolation techniques such as Newton's and Lagrange's formulas for data approximation.
2) To introduce and apply numerical methods for differentiation and integration and analyze their accuracy and applicability.
3) To equip students with efficient techniques for solving ordinary differential equations numerically, including single-step and multi-step methods.
4) To familiarize students with error estimation and convergence analysis in numerical computation.
5) To enhance students' computational thinking and algorithmic skills through practical implementation using numerical software or programming tools.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Recall basic definitions and formulas related to divided differences, interpolation, and numerical differentiation.
2) Explain various numerical methods including Euler's, Taylor's, and Runge-Kutta methods used for solving differential equations.
3) Apply Newton's and Lagrange's interpolation formulas to construct approximating polynomials from given data.
4) Analyze and compare different numerical integration rules (e.g., Trapezoidal, Simpson's) in terms of accuracy and efficiency.
5) Evaluate and implement suitable numerical methods for solving first-order ordinary differential equations.
7) Design and implement algorithms for solving real-world problems involving interpolation, integration, and differential equations using numerical methods.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		No	Minor		Yes
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	Yes
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

Unit No.	Topics	Hours	Marks
I	• Divided differences, Properties of divided difference. • Examples based on Divided differences. • Relation between divided differences and forward difference. • Newton's divided difference formula. • Lagrange's interpolation formula, Inverse interpolation. • Lagrange's inverse interpolation formula.	**9**	**15**
II	• Numerical Differentiation o Derivatives using Gregory-Newton's forward difference formula. o Derivatives using Gregory-Newton's backward difference formula. o Derivative using Sterling's formula. • Numerical Integration o General quadrature formula. o Trapezoidal rule o Simpson 's 1/3 rule o Simpson's 3/8 rule.	**12**	**20**
III	• Taylor's series method. • Picard's method. • Euler's method, Improved Euler's method, Modified Euler's method. • Runge's method, Runge-Kutta method, Higher order Runge-Kutta methods. • Milne's Predictor-Connector method.	**9**	**15**

TEXT BOOKS:

- Dr. V. N. Vedamurthy & Dr. N. Ch. S. N. Iyengar, (2008), ***Numerical methods,*** 2nd Reprint Edition, Vikas Publishing house, New Delhi, India.
- M. K. Jain, S.R.K. Iyengar and R.K. Jain, (2022), ***Numerical Methods,*** 8th Edition, New Age International Publishers, New Delhi.
- Dr. B. S. Grewal, (2019), ***Numerical methods in Engineering & Science***, 11th edition, Khanna Publishers, New Delhi, India.

REFERENCE BOOKS:

- S. D. Conte and Carl De Boor, (2018), ***Elementary Numerical Analysis,*** 3rd Edition, McGraw-Hill, New York.
- S.S. Sastry, (2012), ***Introductory Methods of Numerical Analysis***, 5th Edition, PHI Learning Private Limited, New Delhi.

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Semester V

Course Category	**Minor – 5 Practical**
Title of the Course	**Mathematics-5P: Numerical Analysis – II**
Course Credit	**02**
Teaching Hours per Week	**04**
Total Marks	**25**

Course Objectives

By the end of this course, learners will be able to:

1) Develop foundational understanding of interpolation techniques for data with unequal intervals.
2) Introduce students to numerical approaches for approximating derivatives and definite integrals.
3) Familiarize learners with iterative methods for solving ordinary differential equations (ODEs) numerically.
4) Enhance algorithmic and procedural thinking by engaging students with hands-on numerical computations.
5) Build problem-solving skills in applying numerical methods to real-life and theoretical problems through lab-based learning.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Recall and describe key interpolation and numerical integration formulas used in numerical analysis.
2) Explain the concepts and procedures behind methods such as Euler's, Taylor's, and Runge-Kutta for solving ODEs.
3) Apply various interpolation techniques and numerical methods to solve given problems involving derivatives, integrals, and differential equations.
4) Analyze the accuracy and efficiency of different numerical techniques for solving initial value problems.
5) Evaluate the comparative merits of methods such as Euler's, Modified Euler's, Runge-Kutta, and Milne's Predictor-Corrector for solving first-order ODEs.
6) Design step-by-step algorithms for implementing numerical procedures programmatically or using appropriate software tools.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		No	Minor		Yes
	Skill Enhancement Courses		No	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

Pr. No.	Practical
1	Examples based on Interpolation with unequal intervals.
2	Examples based on Numerical differentiation.
3	Examples based on Numerical integration.
4	Examples based on Taylor's method and Picard's method.
5	Examples based on Euler's, Improved Euler's and Modified Euler's method.
6	Examples based on Runge's method.
7	Examples based on Runge-Kutta's method.
8	Examples based on Milne's method.

TEXTBOOKS:

- Dr. V. N. Vedamurthy & Dr. N. Ch. S. N. Iyengar, (2008), ***Numerical methods,*** 2nd Reprint Edition, Vikas Publishing house, New Delhi, India.
- M. K. Jain, S.R.K. Iyengar and R.K. Jain, (2022), ***Numerical Methods,*** 8th Edition, New Age International Publishers, New Delhi.
- Dr. B. S. Grewal, (2019), ***Numerical methods in Engineering & Science***, 11th edition, Khanna Publishers, New Delhi, India.

REFERENCE BOOKS:

- S. D. Conte and Carl De Boor, (2018), ***Elementary Numerical Analysis,*** 3rd Edition, McGraw-Hill, New York.
- S.S. Sastry, (2012), ***Introductory Methods of Numerical Analysis***, 5th Edition, PHI Learning Private Limited, New Delhi.

B.Sc. Honours/ Honours with Research in Mathematics

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Semester V

Course Category	**Skill Enhancement Course-5 (SEC-5)**
Title of the Course	**Probability & Statistics**
Course Credit	**01**
Teaching Hours per Semester	**15**
Total Marks	**CCE-25**

Course Objectives

By the end of this course, learners will be able to:

1) To introduce foundational concepts of probability and statistics through real-life data and scenarios.
2) To develop computational skills in calculating probabilities, expectations, and standard distributions.
3) To familiarize students with various statistical measures of central tendency and dispersion.
4) To provide conceptual clarity and practical tools for analyzing correlation between variables.
5) To enhance the ability to apply statistical reasoning and interpretation for informed decision-making.

Course Outcomes– COs

Upon completion of this course, the learner will be able to

1) Recall basic formulas and definitions related to probability and statistical measures.
2) Understand and interpret fundamental concepts like conditional probability and correlation.
3) Apply probability rules and distributions (Binomial and Poisson) to solve practical problems.
4) Analyze data sets using statistical tools like standard deviation and coefficient of variation.
5) Evaluate the relationship between two variables using correlation methods.
6) Create meaningful interpretations and comparisons of datasets using central tendency and dispersion measures.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?			Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?			Yes
3	Major	No	Minor	No
	Skill Enhancement Courses	Yes	Ability Enhancement Courses	No
	Value Added Courses	No	Exit/ Vocational Courses	No

4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

Unit No.	Topics	Hours/ Semester	SEE/ CEE Marks
I	• Basic word problems to find probability. • Conditional probability, Independent events. • Theorem of total probability (Without proof), Bayes' Theorem (Without Proof), Examples based on it.	5	10
II	• Mathematical Expectation, Binomial distribution, Poisson distribution. • Measure of central Tendency, Mean, Weighted Mean, Median, Mode, Quartiles, Deciles, Percentiles. • Geometric Mean and Harmonic Mean for Ungrouped Data. • Measure of Dispersion, Range, Mean deviation, Mean deviation about mean, Mean deviation about median, Coefficient of Mean deviation, Standard deviation, Variance, Coefficient of variance.	6	10
III	• Correlation, Types of correlation, Coefficient of Correlation, Methods of Correlation: Scatter Diagram Method, Karl Pearson's Product Moment Method and Spearman's Rank Correlation Method.	4	5

Textbooks:

1) S.C. Gupta and V.K. Kapoor, (2022), ***Fundamentals of Mathematical Statistics (Latest Revised Edition)***, Sultan Chand & Sons, New Delhi, India
2) John E. Freund, (2019), ***Mathematical Statistics with Applications, Pearson Education***, New Delhi, India.

Reference Books:

1) P. L. Meyer, (2017), ***Introduction to Probability and Statistical Applications***, 2nd Edition, Oxford & IBH Publishing Co., NEW DELHI, INDIA.
2) Ronald E. Walpole et al., (2021), ***Probability and Statistics for Engineers and Scientists*** (10th Edition), Pearson Education, Boston, USA
3) Sheldon Ross, (2023), ***A First Course in Probability*** (10th Edition), Pearson Education, London, UK
4) Murray R. Spiegel and Larry J. Stephens, (2021), ***Schaum's Outline of Statistics*** (6th Edition), McGraw-Hill Education, New York, USA

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Semester V

Course Category	**Skill Enhancement Course (SEC) – 5 Practical**
Title of the Course	**Problems on Probability & Statistics**
Course Credit	**01**
Teaching Hours per Semester	**02**
Total Marks	**25**

Course Objectives

1) Introduce fundamental principles of probability and discrete standard distributions.
2) Develop proficiency in statistical measures and data summarization.
3) Build competence in performing correlation analysis using multiple methods.
4) Encourage interpretation of probabilistic models in real-world contexts.
5) Instill analytical skills for interpreting and comparing statistical data.

Course Outcomes– Cos

Upon completion of this course, the learner will be able to

1) Recall definitions of classical probability, conditional probability, and standard distributions.
2) Explain calculation methods for measures of central tendency and dispersion.
3) Apply probability rules and discrete distributions to solve real-life problems.
4) Analyze datasets through dispersion and correlation measures.
5) Evaluate relationships between variables using Pearson and Spearman correlation.
6) Create data-driven interpretations and visual summaries using learned statistical techniques.

1	Employability/Entrepreneurship/Skill Development પર કેન્દ્રિત થયેલ છે કે નહિ?					Yes
2	Value added Courses Imparting Transferable and Life Skills ના ગુણો ધરાવે છે?					Yes
3	Major		No	Minor		No
	Skill Enhancement Courses		Yes	Ability Enhancement Courses		No
	Value Added Courses		No	Exit/ Vocational Courses		No
4	Holistic Education	Yes	Multidisciplinary	No	Interdisciplinary	No
5	દિવ્યાંગ માટે વિષય અંતર્ગત આનુસાંગિક જોગવાઈ કરાયેલ છે?					Yes
6	New India Literacy Programme (NILP) મુજબનો વિષય છે?					Yes
7	Swayam પ્લેટફોર્મ પરના MOOC વિષય પર આધારિત આ વિષય છે?					No
8	ઈન્ડીયન નોલેજ સીસ્ટમ (IKS) પર આધારિત વિષય છે?					No

PN	Practical
1	Example based on conditional probability, Multiplication rule and Independent events.
2	Examples based on Bayes' theorem.
3	Examples based on Binomial distribution.
4	Examples based on Poisson distribution.
5	To find Mean, Weighted Mean, Median, Mode, Quartiles, Deciles, Percentiles, Geometric Mean and Harmonic Mean of given data and analyse the data.
6	To find Range, Mean deviation about mean, Mean deviation about median and Coefficient of Mean Deviation of given data and analyse the data.
7	To find Standard deviation, Variance and Coefficient of variance of given data and analyse the data.
8	To find correlation between two sets of data by Karl Pearson's Correlation Method and Spearman's Rank Correlation Method.

Textbooks:

1) S.C. Gupta and V.K. Kapoor, (2022), Fundamentals of Mathematical Statistics (Latest Revised Edition), Sultan Chand & Sons, New Delhi, India
2) John E. Freund, (2019), Mathematical Statistics with Applications, Pearson Education, New Delhi, India.

Reference Books:

1) P. L. Meyer, (2017), Introduction to Probability and Statistical Applications, 2nd Edition, Oxford & IBH Publishing Co., NEW DELHI, INDIA.
2) Ronald E. Walpole et al., (2021), Probability and Statistics for Engineers and Scientists (10th Edition), Pearson Education, Boston, USA
3) Sheldon Ross, (2023), A First Course in Probability (10th Edition), Pearson Education, London, UK.
4) Murray R. Spiegel and Larry J. Stephens, (2021), Schaum's Outline of Statistics (6th Edition), McGraw-Hill Education, New York, USA