SOMAIYA VIDYAVIHAR

K J Somaiya College of Science & Commerce

Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

Learning Outcomes based Curriculum Framework

(LOCF)

For

F.Y.B.Sc. Mathematics (MINOR)

Undergraduate Programme

From

Academic year

2023-24

Vision & Mission

Mission:

- Equip the student with knowledge and skills of their chosen vocation
- Inculcate values.
- Provide them opportunities for all, round growth and prepare them for life.

Vision:

- To equip the students with advanced knowledge and skills in their chosen vocation.
- To provide value-based education and opportunities to students.
- To help them to face challenges in life.
- To nurture a scientific attitude, temperament and culture among the students.
- To continually review, develop and renew the approach to build India of the Founder's dream.

Goals and Objectives:

- To build a strong Academia-Industry bridge.
- To provide flexibility in the courses offered and proactively adapt to the changing needs of students and the society.
- To establish a centre for multidisciplinary activities.
- To mould individuals who would nurture the cultural heritage of our country and contribute to the betterment of society.

SOMAIYA VIDYAVIHAR

K J Somaiya College of Science & Commerce

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Somaiya TRUST

Board of studies in Mathematics

Undergraduate and Postgraduate

	Name	Designation	Institute/Industry
Head of the Department			
1	Subhash Krishnan	Chairman	K. J. Somaiya College of Science and Commerce
Subject Expert nominated by Vice-Chancellor			
1	Dr. Jyotshana Prajapat	Professor	University of Mumbai
Subject experts			
1	Prof. Ravi Rao	Professor	TIFR(retired)
2	Prof. Eknath Ghate	Professor	TIFR
3	Prof.Amitava Bhattacharya	Professor	TIFR
4	Prof. Amiya Bhowmick	Professor	ICT
5	Prof. Shripad Garge	Professor	IITB
6	Mr. Nimesh G. Punjani	Assistant Professor	Lala Lajpatrai College
7	Mrs. Maya Nair	Assistant Professor	SIES College
Representative from Industry/corporate sector/allied area			
1	Mr. Ananthkrishnan Subramanian	Director, Program Management	ZEOTAP
Meritorious Alumnus			
1	Mr. Sudhir Thakur	Jr. College lecturer	SIES Junior College of Commerce and Economics

Faculty of the specialisation			
1	Mrs. Sudha Agrawal	Associate Professor	K. J. Somaiya College of Science and Commerce
2	Dr. Mrs. Reema Khanna	Associate Professor	K. J. Somaiya College of Science and Commerce
3	Mr. Makarand Niphadkar	Associate Professor	K. J. Somaiya College of Science and Commerce
4	Mr. Prabhat Upadhayay	Assistant Professor	K. J. Somaiya College of Science and Commerce
5	Mr. Prashant Agre	Assistant Professor	K. J. Somaiya College of Science and Commerce
6	Mrs. Javeria Qureshi	Assistant Professor	K. J. Somaiya College of Science and Commerce

Foreword

Autonomy reflects efforts for excellence in academic performances, capability of self-governance and enhancement in the quality of education. In the year 2012, the UGC and University of Mumbai conferred the Autonomous Status to K. J. Somaiya College of Science and Commerce. Post this recognition and having several accolades to our credit, we made significant changes to our existing syllabi to reflect the changing business, industrial and social needs. A holistic education that provides opportunities to gain and share knowledge, experiment and develop beyond curriculum, is offered at our College.

Autonomous colleges carry a prestigious image for the students and the teachers and we have made a collaborative attempt to maintain a high level of quality in the standard of education that we impart.

Structured feedback obtained from the students, alumni and the experts from the industry and the changes suggested by them were duly incorporated in the syllabi. The Board of Studies constituted for each department meets to carry out in depth discussions about different aspects of the curriculum taking into cognizance the recent trends in the discipline.

The IQAC team has facilitated the conduct of a number of workshops and seminars to equip the faculty with the necessary skill set to frame the syllabi and competencies to deliver the same. Training was also provided to employ innovative evaluation methods pertaining to higher cognitive levels of revised Bloom's

taxonomy. This ensured the attainment of the learning outcomes enlisted in the syllabus. Audits are conducted to critically review the practices undertaken in teaching, learning and evaluation. Innovative learning methodologies such as project-based learning, experiential learning and flip- class learning practiced by a committed fleet of faculty, supported by several hands have been our unique outstanding propositions. All efforts have been made to nurture the academic ambitions as well as the skills in co-curricular activities of the most important stakeholder i. e. student.

With sincere gratitude, I acknowledge the constant support and guidance extended by Shri Samir Somaiya, President- Somaiya Vidyavihar, and all the esteemed members of the Governing board and Academic council of the College. I also would like to acknowledge the Heads of the Departments and all the faculty members for their meticulous approach, commitment and significant contribution towards this endeavour for academic excellence.

Dr. Pradnya Prabhu
Principal

Acknowledgement

At the outset, I would like to thank our Principal Dr. Pradnya Prabhu for her guidance and support during the curriculum restructuring process. I am also grateful to all the esteemed members of the Board of Studies, for their constructive suggestions and contributions.

Above all, I am deeply indebted to all the young and vibrant colleagues in the Department of Mathematics for the long and arduous work they have put in during the compiling of the restructured syllabus.

Mr. Subhash Krishnan
Chairperson
Board of Studies in Mathematics

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Preamble

Mathematics is universally accepted as the queen of all sciences. This fact has been confirmed with the advances made in Science and Technology. Mathematics has become an imperative prerequisite for all the branches of science such as Physics, Statistics, Computer Science, Biology etc. This revised syllabus in Mathematics, B.Sc. Programme aims at catering to the needs of the learner in all these branches. Learners who have completed High School (Science) with Mathematics as one of the courses are eligible to take this programme. In High School the focus is on comprehending different tools to solve a problem whereas in the B.Sc. Mathematics programme emphasis will not only be to generate tools to solve but also to prove rigorously, when one can apply them, what condition will be required to be applied to obtain a desired output.

Education is one of the most critical yardsticks in any country's development. The new National Education Policy (NEP) 2020 is an essential and comprehensive policy framework that aims to revamp the country's educational system from its foundation and to bring it at par with global standards. The larger aim of this policy is to transform the Indian education system by making it more inclusive, flexible and relevant to the changing needs of the society. Some of the key features of this policy are the introduction of vocational training, elective courses, emphasis on cultural studies, development of global skill sets and the promotion of multilingualism.

The policy seeks to bring about significant changes in the Higher Education structure, such as introducing a four-year undergraduate degree Programme, establishing multidisciplinary education and research universities, pooled credit bank and creating a National research Foundation to promote and support

research activities in various fields. The new education policy enables every student to get quality education irrespective of their socio-economic background, gender or disability. NEP 2020 enables teachers to use a variety of learning techniques and experiments.

In the current fast paced world, simply cascading the knowledge in the classroom is not sufficient especially when the global requirements keep changing. Every learner should be encouraged to exchange ideas and thoughts in a collaborative approach. This leads to develop an environment which is cognitive in nature and not a one-way information flow. Keeping all this in mind, the curriculum under Learning Outcome-based Curriculum Framework (LOCF) is designed.
This Learning Outcome-based Curriculum Framework (LOCF) supports the fundamental principle of providing quality education in India. Our focus is to involve young minds to participate, contribute and add value at each stage in the field of their study. The introduction of Choice Based Credit System (CBCS) has maximized the benefits of the newly designed curriculum in multiple folds.
The LOCF will certainly help teachers to envisage the outcome expected from the learners at the end of the programme. For students, it will be a guide which shows how this curriculum will help them acquire all the skills and knowledge which are essential in their personal and academic growth. Higher education qualifications such as Bachelor's Degree Programme are awarded on the basis of demonstrated achievement of outcomes and academic standards; and this is the very essence of this curriculum.

1. Introduction

The B.Sc. Mathematics programme is developed by keeping in mind the interest of learners to explore the field of Mathematics. The framework helps to maintain the standard of degrees/programmes through periodic programme review within a broad framework of agreed/expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The BSc programme is planned in such a way that it allows flexibility and innovation in programme design, syllabi development, teaching-learning process and quality assessment of students' learning levels.

This curriculum framework is developed on the principles of student centric learning pedagogy. The platform intends to empower graduates with the skills required for pursuing Mathematics-related careers, higher education in Mathematics and allied subjects.

Various graduate attributes are emphasised in this framework such as critical thinking, basic psychology, scientific reasoning, moral ethical reasoning, etc. While designing this framework, an important aspect considered was the measurable teaching-learning outcome to ensure employability of the graduates. Implementation of modern pedagogical tools and concepts such as flip-class, hybrid learning, MOOCs and other e-learning platforms are suggested through this framework. The framework also focuses on issues relevant to India and also of the rest of the world.

Every course is designed in such a way that students get decent exposure to each topic by keeping an equilibrium between these topics and thus creating interest to

pursue further education in the field of Mathematics. It covers the basic concepts of Mathematics to establish a strong foundation of the subject and helps students to explore the subject more. Topics varying from Algebra, Linear Algebra, Calculus, Differential Calculus of one variable and multivariable, Integral Calculus of one variable and multivariable, Ordinary Differential Equations, Graph Theory, Numerical Methods, Metric topology, Number Theory and Complex Analysis are taught. Maxima and Latex are taught as skill enhancement courses in semesters V and VI respectively.

The practical sessions will help the students to gain sufficient skills in problem solving and appreciate the real world applications of the concepts taught. Students are also encouraged to improve their scientific writing skills through various assignments. The research-based project work in the curriculum ensures team building attitude within students and utilises every aspect of the team members in the success of any project. The project evaluation method is designed in such a way that it helps in creating a strong background for the research, skills to generate systematic reports and create effective presentation.

2. Learning Outcome based Curriculum Framework

LOCF focuses on curriculum framework, curriculum aims, learning targets and objectives. The curriculum framework also provides examples of effective learning, teaching and assessment practices. As the curriculum development is a collaborative and an on-going enhancement process, the LOCF instructs periodic reviews and revisions of the curriculum in accordance with the ever changing needs of students, teachers and society.

The framework describes how students are given exposure towards core knowledge of the subject, specialisation, choice based learning and other skill

enhancement courses ensuring development of an integrated personality and employability. The template defines expected outcomes for the programme like core competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness along with specific learning course outcomes at the starting of each course. The Learning Outcomes based Curriculum Framework (LOCF) for B.Sc. Mathematics will certainly be a valuable document in the arena of outcome-based curriculum design.

2.1 Nature and extent of B.Sc. Mathematics

Mathematics is the study of quantity, structure, space and change. It has a very broad scope in science, engineering and social sciences. The key areas of study in mathematics are:

1. Calculus
2. Algebra
3. Geometry
4. Ordinary Differential Equations
5. Analysis
6. Combinatorics
7. Financial Mathematics

Degree programs in Mathematics cover topics from Calculus (one variable and multi variable), Algebra, Linear Algebra, Analysis (Real analysis, Complex analysis and Topology of Metric spaces), Number theory, Numerical methods, Ordinary differential equations, Combinatorics, Financial Mathematics, Fourier analysis, Operation research, programming languages such as C programming, Java programming, Python programming and use of Mathematical software such as

Maple, Sage, LaTeX, etc. The depth and breadth of study of individual topics depend on the nature and devotion of learners in specific mathematics programmes. As a part of effort to enhance employability of mathematics graduates, the courses have been designed to include learning experiences, which offer them opportunities in various sectors of human activities. In this context, the experience of the project work in the areas of applications of Mathematics has a key role.

2.2 Programme Education Objectives (PEOs)

The overall aims of B.Sc. with Mathematics as a subject are to:

1. Create a deep interest in learning mathematics.
2. Develop broad and balanced knowledge and understanding of definitions, concepts, principles and theorems.
3. Familiarize the learners with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences.
4. Enhance the ability of learners to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in mathematics.
5. Provide learners sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics.
6. Encourage the learners to develop a range of generic skills helpful in employment, internships and social activities

3. Graduate Attributes in Mathematics

Attributes expected from the graduates of B.Sc. Mathematics Programme are:

GA 1: Proficient in analytical, quantitative and technical skills required for problem solving.

GA 2: Trained to apply a rigorous, critical and logical approach to enquiry

GA 3: Adept in Critical evaluation of the knowledge gained in the advanced fields of Mathematics, IT, Data Science, Machine learning and Management.

GA 4: Implementing the knowledge of Mathematics in Environmental and Socio-economic domains of the society.

GA 5: communicate mathematics and interact effectively, clearly and precisely to an audience of peers and faculty.

GA 6: socially a responsible citizen and help others to comprehend, assimilate and disseminate principles of mathematics and its applications. Help in hypothetical reasoning, logical thinking, explanation, abstractions, theories.

4. Qualification descriptors

Undergraduate degree programmes of either 3 or 4-year duration, with multiple entry and exit points and re-entry options, with appropriate certifications such as:

- a UG certificate is awarded to students who opt to exit after completing 1 year (2 semesters) of study in the chosen fields of study with having secured 44 credits and in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.
- a UG diploma is awarded to students who opt to exit after 2 years (4

semesters) of study with having secured 88 credits and in addition, they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

- a bachelor's degree is awarded after a 3-year (6 semesters) programme of study in major discipline with having secured 132 credits and minimum credit requirements as follows

Sr. No.	Category of Courses	Minimum credit requirements
1	Major Core Course	48
2	Minor Stream Course	20
3	Discipline Specific Elective Course	06
4	Ability Enhancement Course	08
5	Skill Enhancement Course	06
6	Value Education Course	04
7	Vocational Skill Course	08

8	Indian Knowledge System	02
9	Co-curricular Course	20
10	Open Elective Course	10
Total		132

- After completing the requirements of three year Bachelor's degree, candidate who meet the minimum CGPA of 7.5 shall be allowed to continue studies in the fourth year of undergraduate program to pursue and complete Bachelor's degree with honours/research (subject to change)
- a 4-year bachelor's degree (honours) is awarded after eight semesters programme of study with having secured 176 credits and minimum credit requirements as follows:

Sr. No.	Category of Courses	Minimum credit requirements
1	Major Core Course	76
2	Minor Stream Course	24
3	Discipline Specific Elective Course	14

4	Ability Enhancement Course	08
5	Skill Enhancement Course	06
6	Value Education Course	04
7	Vocational Skill Course	08
8	Indian Knowledge System	02
9	Co-curricular Course	24
10	Open Elective Course	10
Total		176

- They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 176 credits, including 12 credits from a research project/dissertation, are awarded UG Degree with Research.

The 4-year bachelor's degree programme is considered a preferred option since it would provide the opportunity to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per the choices of the student.

Upon successful completion of the programme, students receive B.Sc. degree in Mathematics. B.Sc. Mathematics graduates of this department are expected to demonstrate the extensive knowledge of various concepts of Mathematics and its application thus contributing in research, development, teaching, government and public sectors. This programme will establish a foundation for students to further pursue higher studies in Mathematics. The list below provides a synoptic overview of possible employment areas provided by an undergraduate training in Mathematics.

The list below provides a synoptic overview of possible career paths provided by an undergraduate training in Mathematics:

1. Software engineer
2. Data Scientist
3. Data Analyst
4. Meteorologist
5. Teaching
6. Financial Manager/ trader
7. Actuary
8. Investment Analyst
9. Research Scientist
10. Game Designer

Job Roles for B.Sc. Mathematics graduate:

After graduation one can seek a professional career as:

1. Developer - Use mathematical formulas and models to develop platforms for other areas.

2. Manager - Apply mathematical theories and techniques to solve practical problems in business, engineering, the sciences, or other fields
3. Analyst - Develop mathematical or statistical models to analyse data
4. Information officer - Interpret data and report conclusions from their analyses
5. Use data analysis to support and improve business decisions
6. Researcher -
    - Applied Mathematician - Applied mathematicians use theories and techniques, such as mathematical modelling, to solve practical problems. These mathematicians typically work with individuals in other occupations to solve these problems. For example, they may work with chemists and materials scientists and chemical engineers to analyse the effectiveness of new drugs. Other applied mathematicians may work with industrial designers to study the aerodynamic characteristics of new automobiles.
    - Theoretical mathematicians - Theoretical mathematicians do research to identify unexplained issues in mathematics and resolve them. They are primarily concerned with exploring new areas and relationships of mathematical theories to increase knowledge and understanding about the field. Although some may not consider the practical use of their findings, the knowledge they develop can be an important part of many scientific and engineering achievements.

Higher Education options for B.Sc. Mathematics graduate:

1. M.Sc. in Math/Computer Science/ IT
2. MBA
3. MCA

4. B. Ed.
5. Masters in Data Science

The learners who complete three years of full-time study of an undergraduate programme of study will be awarded a Bachelor's degree in Mathematics.

5. Programme Specific outcomes (PSOs)

After the successful completion of modules in different courses of B.Sc. Mathematics, the learner will be able to:

PSO I Emphasize basic concepts of Mathematics in various situations.

PSO II Apply rigorous treatment to the concepts of Mathematics and appreciate the role of mathematical proofs in formal deductive reasoning and distinguish a coherent argument from a fallacious one.

PSO III Articulate mathematical principles and create mathematical models/games through experiential learning.

PSO IV Formulate mathematical models to obtain feasible solutions to real-world problems amenable to mathematical analysis.

PSO V Proficiently write programs in languages like C, Java, R, Python to implement various concepts of Mathematics.

PSO VI Explore different Mathematical software tools for self-learning.

5.1 Course Mapping

Semester	PSO / Course	I	II	III	IV	V	VI
I	MJ I						
	MJ II						
	MN I	√	√	√	√		√
	MN II	√	√	√	√		√
	AEC I						
	AEC II						
	VEC						
	CC						
II	OE						
	MJ I						
	MJ II						
	MN I	√	√	√	√		√
	MN II	√	√	√	√		√
	AEC I						
	AEC II						
	VEC						
	IKS						
	CC						
	OE						

6. Structure of B.Sc. Mathematics programme

The curriculum framework is designed around the choice-based credit system (CBCS). The programme consists of three years UG having six semesters (two semesters per year) or four years UG (Honours) having eight semesters (two semesters per year). Credit Distribution for Eight Semester is as follows:

Semester	MJ	DSE	SEC	VSC	MN	AEC	VEC	IKS	CC	FP	INT/ APT	OE	Total
I	6	-	-	-	6	4	2	-	2	-	-	2	22
II	6	-	-	-	6	3	2	1	2	-	-	2	22
III	6	-	3	2	4	1	-	1	2	-	-	3	22
IV	6	-	3	2	4	-	-	-	2	2	-	3	22
V	12	-	-	-	-	-	-	-	-	2	8	-	22
VI	12	6	-	4	-	-	-	-	-	-	-	-	22

BSc with Honours – 22 credits in Sem VII and VIII

BSc with Research – 22 credits in Sem VII and VIII

To acquire a degree in B.Sc. Mathematics a learner must study

1. **Major Core Courses (MJ):**

   a) A course which is required to be opted by a candidate as a major core course. The course designed under this category aims to cover the basics that a student is expected to imbibe in that particular subject or discipline.

   b) Students may be allowed to change majors within the broad discipline at the end of the second semester by giving her/him sufficient time to explore interdisciplinary courses during the first year.

   c) There are twenty four Major Core courses (MJ), two each, in semesters I to IV; and four each in semesters V and VIII.

   d) Each Major Core Courses is compulsory.

   e) Each Major Core Course from semester I to VI is comprised of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1 credit for practical of two hours per week in every semester.

   f) Each Major Core Course from semester VII and VIII is comprised of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1.5 credit for practical of three hours per week in every semester.

   g) The purpose of fixing major core papers is to ensure that the institution follows a minimum common curriculum so as to adhere to common minimum standards with other universities/institutions.

2. **Minor Stream Course (MN):**

a) A course is chosen by a candidate from the interdisciplinary stream as a minor course. Minor Stream courses help a student to gain a broader understanding beyond the major discipline.

b) Students who take a sufficient number of courses in an interdisciplinary area of study other than the chosen major will qualify for a minor in that discipline.

c) Students may declare the choice of the minor stream course at the end of the second semester after exploring various courses.

d) There are two each Minor stream course (MN), in semesters I and II. This Minor stream is comprised of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1 credit for practical of two hours per week in every semester.

e) There is one each Minor stream course (MN) in semester III and IV. This Minor stream is comprised of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 2 credits for practical of four hours per week in every semester.

f) Each Minor stream Courses is compulsory.

3. Ability Enhancement Courses (AEC)

a) The courses aim at enabling the students to acquire and demonstrate the core linguistic skills, including critical reading and expository and academic writing skills, that help students articulate their arguments

and present their thinking clearly and coherently and recognize the importance of language as a mediator of knowledge and identity.

b) Students are required to achieve competency in a Modern Indian Language (MIL) and in the English language with special emphasis on language and communication skills.

c) There are five AE courses spread over three semesters (I to III).

d) Each student is supposed to take two AE in semester I - English language and Modern Indian language of 2 credits each.

e) There are two AE in semester 2 - English language of two credits and Modern Indian language of 1 credit.

f) There is one AE in semester 3 - Modern Indian language of 1 credit.

4. Value Education Courses (VEC)

a) The course seeks to equip students with the ability to apply the acquired knowledge, skills, attitudes and values required to take appropriate actions for mitigating the effects of environmental degradation, climate change, and pollution, effective waste management, conservation of biological diversity, management of biological resources, forest and wildlife conservation, and sustainable development and living.

b) The VEC courses offered are:

VEC I- Environmental Science I (2 credits) (Semester I),

VEC II- Environmental Science II (2 credits) (Semester II).

5. Co-Curricular courses (CC):

a) They are designed to provide skill-based knowledge and contain both lab/hands on training/field work.

b) The main purpose of these courses is to provide life skills in hands-on mode to increase employability.

c) There are two CC each in semester I to III – NCC (compulsory 1 credit course) and Other one from Music/Sports training program/Yoga/ Study Circle

d) There are three CC each in semester IV – NCC (compulsory 1 credit course), second one from Music/Sports training program/Yoga/ Study Circle of 1 credit and third one is Field project of 2 credits.

e) There are two CC semester V – Internship/ Apprenticeship (8 credit) and Field project (2 credit)

6. Open Elective (OE)

a) They are designed to provide multidisciplinary education.

b) Students can opt for one interdisciplinary Open Elective Course (OE) in each of semester I and II of two credits each.

c) Students can opt for one interdisciplinary Open Elective Course (OE) in each of the semester III and IV of three credits each.

d) Open courses are offered in cognate disciplines by different departments in the college.

7. Indian Knowledge System (IKS)

a) They are designed to recognize the rich heritage of ancient and eternal Indian knowledge and thought as a guiding principle.

b) Students can opt for one General IKS in semester II – Indian cultural Heritage of one credit.

c) There is one IKS based on a major subject in semester III of 1 credit.

8. Skill Enhancement Course (SEC):

a) They are designed to provide skill-based knowledge pertaining to the Major course to the learner.

b) The main purpose of these courses is to provide life skills in hands-on mode to increase employability.

c) There are Two skill enhancement courses offered. Each student is supposed to take one SEC in each semester III and IV of 3 credits each (2 credit theory and 1 credit practical).

9. Discipline Specific Elective Courses (DSE):

a) Elective courses offered under the major course subject of study.

b) There are two discipline specific elective courses (DSE), offered in semesters VI of 2 credits theory and 1 credit practical.

c) There is one discipline specific elective course (DSE), offered in semesters VII and VIII each of 2 credits theory and 2 credit practical.

d) There is one advanced level disciplinary course – Research Methodology of 4 credits offered in semester VII.

10. Vocational Skill Course (VSC)

a) Vocational courses are designed to provide practical, hands-on training, competencies, and proficiency to students, ultimately enhancing their skills and employability.

b) These courses are tailored to prepare individuals for specific careers and industries.

c) There are two VSC offered, one each in semester III to IV, each one is of two credits.

d) There is one VSC offered in semester VI of 4 credits.

11. On Job Training (OJT)

a) On Job training of 4 credits is offered in semester VIII to enhance the specific skills and competencies required for a particular job

b) OJT bridges the gap between theory and practical application, promoting a deeper understanding of concepts.

6.1 Content

Sr. No	Semester	Course number	Course Code	Course title
1	I	MJ I		Course from Statistics/ Physics/ Chemistry
2		MJ II		Course from Statistics/ Physics/ Chemistry
3		MJ P		Based on MJ I and MJ II
4		MN I	23USIMTMN1CAL1	Calculus- I
5		MN II	23USIMTMN2ALG1	Algebra- I
6		MN P	23USIMTMNP	Based on MN I and MN II
7		AEC I		Communication in English Level I
8		AEC II		Modern Indian Language Level I (Hindi/Marathi)
9		VEC		Environmental Science I
10		CC I		NCC
11		CC II		Music/Yoga/Sports Training Program Level I/ Study Circle
12		OE		Social Media Advertising/ Introduction to microeconomics

13	II	MJ I		Course from Statistics/ Physics/ Chemistry
14		MJ II		Course from Statistics/ Physics/ Chemistry
15		MJ P		Based on MJ I and MJ II
16		MN I	23US2MTMN1CAL2	Calculus- II
17		MN II	23US2MTMN2LALGI	Linear Algebra- I
18		MN P	23US2MTMNP	Based on MN I and MN II
19		AEC I		Communication in English Level II
20		AEC II		Modern Indian Language Level II (Hindi/Marathi)
21		VEC		Environmental Science - II
22		IKS		Indian Cultural Heritage
23		CC I		NCC
24		CC II		Music/Yoga/Sports Training Program Level I/ Study Circle
25		OE		Indian Finance system and budget/ Brand Management

6.2 Credit distribution for B.Sc. Mathematics

Semester	Course number	Course title	Credits		
			Theory	Practical	Total
I	MJ I	Course from Statistics/ Physics/ Chemistry	2	1	3
	MJ II	Course from Statistics/ Physics/ Chemistry	2	1	3
	MN I	Calculus I	2	1	3
	MN II	Algebra I	2	1	3
	AEC I	Communication in English Level I	2		2
	AEC II	Modern Indian Language Level I	2		2
	VEC	Environmental Science - II	2		2
	CC I		1		1
	CC II		1		1
	OE		2		2
	Total				**22**

II	MJ I	Course from Statistics/ Physics/ Chemistry	2	1	3
	MJ II	Course from Statistics/ Physics/ Chemistry	2	1	3
	MN I	Calculus II	2	1	3
	MN II	Linear Algebra I	2	1	3
	AEC I	Communication in English Level II	2		2
	AEC II	Modern Indian Language Level II	1		1
	VEC	Environmental Science - II	2		2
	IKS	Indian Cultural Heritage	1		1
	CC I		1		1
	CC II		1		1
	OE		2		2
	Total				**22**

6.3 Semester Schedule

Semester	Major Core Courses (MJ)	Minor Stream Courses (MN)	Ability Enhancement Compulsory Course (AEC)	Value Education Course (VEC)	Indian Knowledge e System (IKS)	Co-Curricular Course (CC)	Open Elective (OE)
I	I] MJI Course from Statistics/ Physics/ Chemistry 2] MJ2 Course from Statistics/ Physics/ Chemistry	I] MNI Calculus – I 2] MN2 Algebra -I	I] AEC I Communication in English Level I 2] AEC II Modern Indian Language Level I	Environment Science I		I] NCC II] Music/ Yoga/ Sports Training Program Level I/ Study Circle	Social Media Advertising/ Introduction to microeconomics
II	I] MJI	I] MNI	I] AEC I	Environm	Indian Cultural	I] NCC II] Music/	Indian Finance

	Course from Statistics/ Physics/ Chemistry 2] MJ2 Course from Statistics/ Physics/ Chemistry	Calculus II 2] MN2 Linear Algebra -I	Communication in English Level II 2] AEC II Modern Indian Language Level II	ent Science II	Heritage	Yoga/ Sports Training Program Level I/ Study Circle	system and budget/ Brand Management

6.4 Course Learning Objective

The three-year undergraduate Mathematics programme is designed to familiarize and strengthen students with core Mathematics concepts and rigorously prove results in Mathematics. The objective of structured syllabus in Mathematics is to make the concepts and basics of Mathematics clear and interesting to students and also to ensure the development of vertical growth in the subject. The idea behind this is to enable students to develop analytical skills and critical thinking.

It is our attempt that students achieve this objective through systematic reading and class lectures and through feedback on their written work-assignments, project/research papers, presentations, discussions, debates, etc. our intention is to enable students to formulate cogent arguments, presenting the necessary evidence to establish these, based on a training in Mathematics.

7. Detailed B.Sc. Mathematics Syllabus

F. Y. B.Sc. Syllabus with effect from the Academic year 2023–2024

Syllabus – F. Y. B.Sc. Mathematics

Course No.	Course Title	Course Code	Credits	Periods (1 Hr)	Module	Lectures per module (1 hr)	Examination		
							Internal Marks	External Marks	Total Marks
SEMESTER I									
Minor Stream courses THEORY									
I	Calculus –I	23USI MTM NICALI	2	30	2	15	20	30	50
II	Algebra-I	23USI MTM N2ALG I	2	30	2	15	20	30	50
Minor Stream courses PRACTICAL									
		23USI MTM NP	2	60			CIE		50
SEMESTER II									
Minor Stream courses THEORY									
I	Calculus – II	23US2 MTM	2	30	2	15	20	30	50

		N2CAL II							
II	Linear Algebra – I	23US2 MTM N2LAL GI	2	30	2	15	20	30	50
Minor Stream courses PRACTICAL									
	Mathematics Practical	23US2 MTM NP	2	60			CIE		50

F.Y. B. Sc. (Mathematics) SEMESTER I

Minor Stream Course- I

COURSE TITLE: Calculus-I

COURSE CODE: 23USIMTMNICALI [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: CLO 1: Analyse convergence of sequence and its subsequence. CLO 2: Prove results on Cauchy sequences in R. CLO 3: Test convergence of series using different tests. CLO 4: Apply results proved in mathematical sciences and real world modelling

Module 1	Sequence and Subsequence of Real numbers	[15 L]

Learning Objectives:

The learner should be able to:

1. Understand the meaning of a sequence
2. Understand the concept of limit of a sequence
3. Apply the LUB property to monotonic bounded sequences
4. Obtain e, through a sequence

	5. Understand the fact that for a convergent sequence, all subsequences give the same limit	
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Use of sequential approach for solving problems 2. Apply tools developed in module I for proving results and solving problems 3. Solve problems based on subsequences.		
1.1	ε-neighbourhood of a point in $\mathbb{R}$. Upper bound and lower bound of a subset of $\mathbb{R}$. Supremum (lub) and infimum (glb) of a non-empty subset of $\mathbb{R}$. Characterization of lub and glb in terms of ε. Archimedean property of real numbers.	[3L]
1.2	Sequence of real numbers, $\varepsilon - n_0$ definition, limit of a sequence, Uniqueness of Limit. Bounded Sequence, Convergent sequence is bounded. Algebra of convergent sequences (Self-Study). The number e as a limit of a sequence. Monotonic sequences, every monotone bounded sequence is convergent. Examples of sequence of rational numbers converging to $\sqrt{a}$, $a \in R$. Standard examples such as a^n, $a^{1/n}$, $n^{1/n}$, $(n!)^{1/n}$. Statement of Density Theorem (Results and problems part of project), Every real number can be expressed as a limit of a sequence of rational numbers and also as limit of sequence of irrational numbers.	[8L]
1.3	Subsequence of a sequence. Convergence of a sequence implies convergence of its subsequence but not conversely. Convergence of (x_{2n}), (x_{2n-1}) to the same limit p implies convergence of (x_n) to p. Every bounded sequence has a convergent subsequence.	[4L]

Reference Books:

- R.G. Bartle and D.R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.
- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- R. R. Goldberg; Methods of Real Analysis; Oxford and IBH.
- Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press.
- Peter D Lax, Maria Shea Terrel; Calculus with applications, Springer

Additional Reference books:

- H. Anton, I. Bivens and S. Davis; Calculus; John Wiley and Sons, Inc.
- Ghorpade, Sudhir R., Limaye, Balmohan V.; A Course in Calculus and Real Analysis; Springer.
- T. M. Apostol; Calculus (Vol. I); John Wiley and Sons (Asia) P. Ltd.
- Maron; Calculus of one variable Arihant
- Shanti Narayan and Raisinghania; Elements of Real Analysis; S. Chand

Module 2	Cauchy Sequence and Series of real numbers	[15L]

Learning Objectives

The learner should be able to:

1. Prove "Cauchy's criteria for convergence of sequence
2. Understand that a sequence can be written as a series and vice versa
3. Prove the summability of series in terms of sequences of partial sums for simple examples
4. Recognize the appropriate tests which can be applied for particular problems

5. Appreciate the importance of Geometric series and p-series in solving problems on comparison test 6. Understand that these tests are not exhaustive		
Learning outcomes The learner will be able to: 1. Determine whether the sequence is Cauchy 2. Analyse the given problem on convergence of series with appropriate choice of test		
2.1	Definition of a Cauchy sequence. Every convergent sequence is Cauchy. Every Cauchy sequence is bounded. If a subsequence of a Cauchy sequence is convergent then the sequence itself is convergent. Every Cauchy sequence of real numbers is convergent. Completeness of R.	**[6L]**
2.2	Series of real numbers. Terms of a series and partial sums. Summability / Convergence of a real series in terms of convergence of its partial sums. Convergence of series implies convergence of n^{th} term to zero, and converse is false. Simple examples of convergent series and divergent series without involving tests. Sum of two convergent series is convergent. If every term of a convergent series is multiplied by a constant, then the resultant series is convergent. Term wise product of two convergent series need not result into a convergent series. Geometric series; it converges if and only if the the common ratio lies in $(-1, 1)$. Series of nonnegative terms. Cauchy's condensation test. p-series converges if and only if $p > 1$. Comparison test in simple form. Alternating series and Leibnitz' test. Absolute	**[9L]**

	convergence and conditional convergence. Absolute convergence implies conditional convergence and converse is false.Ratio test and root test (Statement only) and problems based on these tests.	

Reference Books:

- R.G. Bartle and D.R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.
- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- R. R. Goldberg; Methods of Real Analysis; Oxford and IBH.
- Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press.
- Peter D Lax, Maria Shea Terrel; Calculus with applications, Springer

Additional Reference books:

- H. Anton, I. Bivens and S. Davis; Calculus; John Wiley and Sons, Inc.
- Ghorpade, Sudhir R., Limaye, Balmohan V.; A Course in Calculus and Real Analysis; Springer.
- T. M. Apostol; Calculus (Vol. I); John Wiley and Sons (Asia) P. Ltd.
- Maron; Calculus of one variable Arihant
- Shanti Narayan and Raisinghania; Elements of Real Analysis; S. Chand

Question Paper Template

F.Y. B. Sc. (Mathematics) SEMESTER I

Minor Stream Course- I

COURSE TITLE: Calculus-I

COURSE CODE: 23USIMTMNICAL1 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	3	5	5	5	5	25
II	2	3	5	5	5	5	25
Total marks per objective	4	6	10	10	10	10	50
% Weightage	8%	12%	20%	20%	20%	20%	100

F.Y. B. Sc. (Mathematics) SEMESTER I

Minor Stream Course- II

COURSE TITLE: Algebra-I

COURSE CODE: 23USIMTMN2ALG1 [CREDITS - 02]

Course Learning Outcomes	
After the successful completion of the Course, the learner will be able to:	
CLO 1:	Apply the properties of natural numbers, integers and prime numbers
CLO 2:	Solve problems on linear Diophantine equations.
CLO 3:	Analyse various algebraic properties of polynomials and find roots using various tools.
CLO 4:	Comprehend complex numbers; its polar representation and algebraic properties and appreciate geometric interpretation through related problems

Module 1	Integers and Diophantine equations	[15 L]

Learning Objectives:

The learner should be able to:

1. Develop the properties of integers and prime numbers 2. Solve problems on linear Diophantine equations		
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Apply the knowledge of integers and prime numbers 2. Solve linear Diophantine equations		
1.1	Statement of well-ordering principle, Principle of finite induction (first and second) as a consequence of well-ordering property	[2L]
1.2	Binomial theorem for non-negative exponents, Pascal Triangle, Multinomial Theorem	[3L]
1.3	Divisibility in integers, division algorithm, greatest common divisor (g.c.d.) and least common multiple (l.c.m.) of two integers, basic properties of g.c.d. such as existence and uniqueness of g.c.d. of integers a & b and that the g.c.d. can be expressed as ma +nb for some m,n $\in$ **Z**, Euclidean algorithm	[4L]
1.4	Primes, Euclid's lemma, Fundamental theorem of arithmetic, The set of primes is infinite	[2L]
1.5	Linear Diophantine equation $ax + by = c$ The linear Diophantine equation $ax + by = c$ has solution if and only if $d \mid c$, where $d = GCD(a, b)$. If x_0, y_0 is any particular solution then any solution of the given Diophantine equation is given by $x = x_0 + (\frac{b}{d})t$ and $y = y_0 - (\frac{a}{d})t$, for varying t. Solving examples.	[4L]

Reference Books:

- An Introduction to the Theory of Numbers by G. H. Hardy and E. M. Wright, fourth edition, Oxford at the Clarendon Press
- Elementary Number theory by David Burton Seventh Edition, McGraw Hill Education (India) Pvt Ltd.

Additional Reference books::

- Niven and S. Zuckerman; Introduction to theory of numbers; John Wiley & Sons, Inc.

Module 2	Polynomials and Complex Numbers	[15L]

Learning Objectives

The learner should be able to:

1. Analyse various algebraic properties of polynomials and find roots using various tools
2. Appreciate geometric interpretation of complex numbers through related problems

Learning outcomes

The learner will be able to:

1. Obtain roots of polynomials with real, rational or integer coefficients using various techniques
2. Compute complex roots of unity, and roots of any complex number in general

2.1	Definition of a polynomial, polynomials over **R**, Algebra of polynomials, degree of polynomial, basic properties, Division algorithm in **R**[X] (without proof), and g.c.d. of two polynomials and its basic properties (without proof), Euclidean algorithm (without proof), applications	[4L]
2.2	Roots of a polynomial, relation between roots and coefficients, multiplicity of a root, Remainder theorem, Factor theorem, A polynomial of degree n has at most n roots, Rational Root Theorem, Relation between roots and coefficients of a polynomial	[5L]
2.3	Review of Complex numbers, Complex roots of a polynomial in **R**[X] occur in conjugate pairs, Statement of Fundamental Theorem of Algebra, A non-constant polynomial in **R**[X] can be expressed as a product of linear and quadratic factors in **R**[X]	[3L]
2.4	De Moivre's Theorem, roots of unity, sum of all the roots of unity	[3]

Reference books

- Titu Andreescu, Dorin Andrica; Complex numbers from A to Z; Birkhauser
- Michael Artin; Algebra; Birkhauser(Section 11.2)

Additional Reference books:

- G. Birkhoff and S. Maclane; A survey of Modern Algebra; AMS Chelsea Publication
- Brown and Churchill; Complex variables and Applications; McGraw Hill.

Question paper Template

F.Y. B. Sc. (Mathematics) SEMESTER I

Minor Stream Course- II

COURSE TITLE: Algebra-I

COURSE CODE: 23USIMTMN2ALG1 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	3	5	5	5	5	25
II	2	3	5	5	5	5	25
Total marks per objective	4	6	10	10	10	10	50
% Weightage	8%	12%	20%	20%	20%	20%	100

F. Y. B. Sc. (Mathematics)

SEMESTER I - Practical

COURSE CODE: 23USIMTMNP Credits- 02

Course Learning Outcomes	
After the successful completion of the Course, the learner will be able to: 1. Apply the results proved to the other sciences 2. Solve modern and classical problems	
Learning Objectives: The Practical is intended to 1. Solve problems based on the concepts learnt 2. Apply the concepts in various situation	
Learning Outcome: After the successful completion of the practical, the learner will be able to: 1. Apply the results proved to the other sciences 2. Create examples and counterexamples 3. Solve modern and classical problems	
Minor Core Course I	**Calculus- 1**
1.1 Problems based on ε-neighbourhood, real numbers, Supremum, Infimum, Archimedean property	
1.2 Problems on Sequence and Subsequence of real numbers	
1.3 Problems on Cauchy Sequence	

1.4 Series I
1.5 Series II
1.6 Formal/Mathematical proof writing such as : a. Monotone Convergence Theorem b. Monotone Subsequence Theorem and Bolzano-Weierstrass Theorem c. p-series convergence d. Leibniz test

Minor Core Course II	Algebra-I
2.1 Induction, Binomial Theorem, Multinomial Theorem	
2.2 G.C.D, L.C.M, Primes	
2.3 Diophantine equations	
2.4 Roots of Polynomials	
2.5 Complex numbers	
2.6 Mathematical writing/ Formal Proof writing such as Binomial Theorem and Euclid's Lemma	
2.7 Mathematical writing/ Formal Proof writing such as Rational Root Theorem and De' Moivre's Theorem	
Reference Books: • R.G. Bartle and D. R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.	

- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- An Introduction to the Theory of Numbers by G. H. Hardy and E. M. Wright, fourth edition, Oxford at the Clarendon Press
- Elementary Number theory by David Burton Seventh Edition, McGraw Hill Education (India) Pvt Ltd.

F.Y. B. Sc. (Mathematics) SEMESTER II

Minor Stream Course- I

COURSE TITLE: Calculus-II

COURSE CODE: 23US2MTMNICAL2 [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Prove various results of limits and continuity using the $\varepsilon - \delta$ definition and sequential criterion. 2. Prove Chain rule, inverse function theorem, Leibnitz theorem and Mean value theorem. 3. Apply Taylor's theorem to generate power series expansion of standard functions. 4. Apply results proved, concepts defined to solve problems.

Module 1	Limits and continuity of real valued functions of one variable	[15L]

Learning Objectives:

The learner should be able to:

1. Understand the $\varepsilon - \delta$ definition of limit and continuity
2. Comprehend the equivalence of $\varepsilon - \delta$ definition of continuity with the sequential continuity
3. prove algebra of limits and continuity

	4. Obtain limit of a function at a point	
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Use $\varepsilon - \delta$ definition as well definition in terms of sequences to find limit of a function 2. Use $\varepsilon - \delta$ definition of continuity as well as sequential continuity to prove the continuity or discontinuity of a function at a given point 3. Find the left-hand and the right-hand limit of a function 4. Construct functions having discontinuity at desired points		
1.1	Definition of limit of a function at a point in terms of $\varepsilon - \delta$. Uniqueness of limit. Boundedness of a function having limit in a neighbourhood. Concept of two sided and one-sided limits. Sum rule, scalar multiplication, product rule and division rule. Sandwich theorem. Computations of limits using rules. Nonexistence of limit of functions such as sin $sin\ \frac{1}{x}$. Infinite limit and limit at infinity.	[7L]
1.2	Definition of continuity of a function at a point in terms of ε - δ and sequence. Equivalence of both the definitions. Continuity of a function at a point in terms of limits. Continuity of a function over an interval, over a set. Algebra of continuous functions. Discontinuity of function such as $si(1/x)$ at the origin, step function etc. Polynomial functions are continuous. Function such as $\lvert x\rvert, x\lvert x\rvert, xsin(1/x)$ etc are continuous. Removable and irremovable discontinuities. Functions having finite number of discontinuities in an interval. Functions having	[8L]

	infinite number of discontinuities in an interval. A function which is discontinuous everywhere. A function which is continuous only at one point. Composition of continuous functions and taking a limit inside a continuous function. Composite of continuous functions is continuous but converse is not true. Two important properties of Continuous functions: Intermediate value property and Continuous function on a closed and bounded interval attains its maximum value and minimum value. (Without proof)	

Reference Books:

- R.G. Bartle and D. R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.
- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- R. R. Goldberg; Methods of Real Analysis; Oxford and IBH.
- Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press.
- Peter D Lax, Maria Shea Terrel; Calculus with applications, Springer

Additional Reference books:

- H. Anton, I. Bivens and S. Davis; Calculus; John Wiley and Sons, Inc.
- Ghorpade, Sudhir R., Limaye, Balmohan V.; A Course in Calculus and Real Analysis; Springer.
- T. M. Apostol; Calculus (Vol. I); John Wiley and Sons (Asia) P. Ltd.
- Maron; Calculus of one variable Arihant
- Shanti Narayan and Raisinghania; Elements of Real Analysis; S. Chand

Module 2	Differentiability of real valued functions of one variable and its application	[15L]

Learning Objectives

The learner should be able to:

1. Analyse geometrical interpretation of derivative
2. Determine Higher order derivatives of a function
3. Obtain Taylor's polynomial and Taylor's series of a function about a point
4. Apply the concept of differentiation to solve real world problems.

Learning outcomes

The learner will be able to:

1. Analyse differentiability of a function
2. Apply results proved to solve mathematical science and real world problems
3. Create examples and counterexamples

2.1	Definition of differentiability of a real valued function of one variable at a point in terms of a limit. Differentiability of a function over an interval or a set. Geometrical interpretation of derivative. Derivative as rate of change and Leibnitz notation. Differentiability implies continuity but not converse. Algebra of derivatives. Chain rule of differentiation. Inverse function theorem. Implicit differentiation. Rolle's Mean Value Theorem, Lagrange's Mean Value Theorem. Higher order derivatives and Leibnitz' rule. Function that are only n times differentiable.	**[9L]**
2.2	Taylor's theorem in Lagrange's remainder form . Taylor polynomial of n^{th} order and Taylor's series about a point. Approximation of a n times differentiable function using Taylor's theorem. Increasing and decreasing functions. Concavity in terms of second derivative. Point	**[6L]**

	of inflection. Local extreme values. Second derivative test and its extension to test using higher order derivatives. Applications of L'Hospital's Rule	

Reference Books:

- R.G. Bartle and D. R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.
- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- R. R. Goldberg; Methods of Real Analysis; Oxford and IBH.
- Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press.
- Peter D Lax, Maria Shea Terrel; Calculus with applications, Springer

Additional Reference books:

- H. Anton, I. Bivens and S. Davis; Calculus; John Wiley and Sons, Inc.
- Ghorpade, Sudhir R., Limaye, Balmohan V.; A Course in Calculus and Real Analysis; Springer.
- T. M. Apostol; Calculus (Vol. I); John Wiley and Sons (Asia) P. Ltd.
- Maron; Calculus of one variable Arihant
- Shanti Narayan and Raisinghania; Elements of Real Analysis; S. Chand

Question Paper Template

F.Y. B. Sc. (Mathematics) SEMESTER II

Minor Stream Course- I

COURSE TITLE: Calculus-II

COURSE CODE: 23US2MTMNICAL2 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	3	5	5	5	5	25
II	2	3	5	5	5	5	25
Total marks per objective	4	6	10	10	10	10	50
% Weightage	8%	12%	20%	20%	20%	20%	100

F.Y. B. Sc. (Mathematics) SEMESTER II

Minor Stream Course- II

COURSE TITLE: Linear Algebra-I

COURSE CODE: 23US2MTMN2LALG1 CREDITS - 02

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Solve problems based on various types of Matrices and their properties. 2. Apply Gauss Elimination method to solve a system of linear equations 3. Verify properties of a vector space and subspaces 4. Compute basis and dimension

Module 1	Matrices	[15L]

Learning Objectives:

The learner should be able to:

1. Learn the various types of matrices, operations on matrices, decomposition,eigen values and eigen vectors

2. Apply the methods to solve systems of linear equations with the geometric interpretation, followed by their simple applications		
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Solve problems on decomposition, eigenvalues and eigenvectors 2. Solve problems based on system of linear equations		
1.1	Matrices with real entries; addition, scalar multiplication and multiplication of matrices; transpose of a matrix, types of matrices: zero matrix, identity matrix, scalar matrices, diagonal matrices, upper triangular matrices, lower triangular matrices, symmetric matrices, skew-symmetric matrices, Invertible matrices; identities such as $(AB)^t = B^t A^t$, $(AB)^{-1} = B^{-1}A^{-1}$. System of linear equations in matrix form, elementary row operations, row echelon matrix, Orthogonal matrix, Hermitian matrix, block multiplication	[5L]
1.2	System of homogeneous and nonhomogeneous linear equations, the solution of system of m homogeneous linear equations in n unknowns by elimination and their geometrical interpretation	[3L]
1.3	Gaussian elimination method, to deduce that the system of m homogeneous linear equations in n unknowns has a non-trivial solution if m < n	[2]
1.4	eigenvalues and eigenvectors of a matrix (proofs of simple properties), examples	[2L]
1.5	LU decomposition, QR decomposition, singular value decompositions, convolutions, two and three dimensional rotations	[3L]

Reference books

- S. Kumaresan; Linear algebra -A geometric approach; Prentice Hall of India(2000)
- Gilbert Strang; Linear Algebra; Wellesy-Cambridge Press
- M.K.Jain, S.R.K Iyengar, R.K.Jain; Numerical Methods(Problems and Solutions); New Age International (P) Limited, Publishers

Additional Reference books

- K Hoffman and R Kunze ; Linear algebra; Prentice-Hall
- Sheldon Axler; Linear Algebra Done Right; Springer

Module 2	Vector Spaces	[15L]

Learning Objectives

The learner should be able to:

1. Comprehend the concept of vector space and subspace
2. Test the linear independence and generating property leading to the study of basis and dimension

Learning outcomes

The learner will be able to:

1. Solve problems related to various concepts in vector spaces using definitions and properties
2. Determine basis, dimension and rank of a matrix

2. 1	Definition of a real vector space, examples such as $\mathbf{R}^n$, $\mathbf{R}[X]$, $M_{m\times n}[\mathbf{R}]$, space of all real valued functions on a non-empty set(e.g. [a,b]),	[5L]

	Finite linear combinations of vectors in a vector space; the linear span L(S) of a non-empty subset S of a vector space	
2.2	Subspace: definition, examples: lines, planes passing through origin as subspaces of $\mathbf{R}^2$,$\mathbf{R}^3$ respectively; Subspaces of $M_n[\mathbf{R}]$; $\mathbf{P}_n[X] = \{a_0 + a_1X + \cdots + a_nX^n / \ a_i \in \mathbf{R} \ \forall \ 0 \leq i \leq n\}$ as a subspace of $\mathbf{R}[X]$ Eigenspace associated to an eigenvalue as a subspace of $\mathbf{R}^n$ L(S) is a subspace of a vector space. The space of all solutions of the system of m homogeneous linear equations in n unknowns as a subspace of $\mathbf{R}^n$. Properties of a subspace such as necessary and sufficient condition for a non empty subset to be a subspace of a vector space, arbitrary intersection of subspaces of a vector space is a subspace, union of two subspaces is a subspace if and only if one is a subset of the other	**[5L]**
2.3	Generating set, linearly independent/linearly dependent subsets of a vector space	**[2L]**
2.4	Basis and dimension of a vector space, applications	**[3L]**

Reference books

- S. Kumaresan; Linear algebra -A geometric approach; Prentice Hall of India(2000)
- Gilbert Strang; Linear Algebra; Wellesy-Cambridge Press

Additional Reference books:

- K Hoffman and R Kunze ; Linear algebra; Prentice-Hall
- Sheldon Axler; Linear Algebra Done Right; Springer

Question Paper Template

F.Y. B. Sc. (Mathematics) SEMESTER II

Minor Stream Course- II

COURSE TITLE: Linear Algebra-I

COURSE CODE: 23US2MTMN2LALG1 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	3	5	5	5	5	25
II	2	3	5	5	5	5	25
Total marks per objective	4	6	10	10	10	10	50
% Weightage	8%	12%	20%	20%	20%	20%	100

F. Y. B. Sc. (Mathematics)

SEMESTER II - Practical

COURSE CODE: 23US2MTMNP Credits- 02

Course Learning Outcomes	
After the successful completion of the Course, the learner will be able to: 1. Apply the results proved to the other sciences 2. Solve modern and classical problems	
Learning Objectives: The Practical is intended to 1. Solve problems based on the concepts learnt 2. Apply the concepts in various situations	
Learning Outcomes: After the successful completion of the practical, the learner will be able to: 1. Apply the results proved to the other sciences 2. Create examples and counterexamples 3. Solve modern and classical problems	
Minor Core Course I	**Calculus -2**
1.1 Problems based on limits	
1.2 Problems based on continuity	
1.3 Problems on differentiability	
1.4 Problems on mean value theorems and higher order derivatives	

1.5 Formal/Mathematical Proof writing such as: Chain rule, Inverse function theorem	
Minor Core Course II	**Linear Algebra -I**
2.1 Problems based on matrices, geometric interpretation of system of Equations	
2.2 To find the solution set of a given system of linear equations.	
2.3 Determine if the given set forms a vector space under given Operations	
2.4 Problems on subspaces	
2.5 To find a basis and dimension of a vector space	
2.6 Mathematical writing/ Formal Proof writing such as -a set is linearly dependent if and only if one of the elements is a linear combination of the other elements. Proving or disproving the converse	
2.7 Mathematical writing/ Formal Proof writing such as -If the dimension of a subspace of a vector space is same as the dimension of the vector space, then the subspace is same as the vector space	

Reference Books:

- R.G. Bartle and D. R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd

- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- S. Kumaresan; Linear algebra -A geometric approach; Prentice Hall of India(2000)
- Gilbert Strang; Linear Algebra; Wellesy-Cambridge Press

8. Teaching learning process

The pedagogic methods adopted, involve direct lectures, tutorial discussions, as well as technology- supported presentations. We believe that education is interactive and all sessions between students and teachers are based upon reciprocity and respect.

1) The lectures (of 1 hr duration) delivered to one whole class at a time systematically deal with the themes of the syllabus. This constitutes the core of the teaching- learning process. The students are provided with bibliographic references and encouraged to go through at least some readings so that they could be more interactive and ask more relevant questions in the class. This also helps obtain knowledge beyond the boundaries of the syllabi.

2) Wherever needed, teachers use audio-video based technology devices (e. g. power point, YouTube videos) to make their presentations more effective. Some courses require that students see a documentary or feature film and course themes are structured so that discussions of these will further nuance the critical engagement of students with ideas introduced in their textual materials.

3) Remedial coaching, bridge courses are adopted to enhance the scope of learning for the learners. Remedial sessions are conducted to offer assistance on certain advanced topics. Bridge courses facilitate to develop a concrete basis for the topics to be learnt in the coming academic year.

9. Assessment Methods

Evaluation Pattern: Theory

- Assessments are divided into two parts: Mid Semester Examination (MSE) and End Semester Examination (ESE).
- The Mid Semester Examination shall be conducted by the College at the Mid of each semester (20 M) – Duration: 30 Min.
- The End Semester Examination shall be conducted by the College at the end of each semester. (30M) Duration: 1 hour

End Semester Examination Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	1	5 M x 5 Q = 25	3 M x 5 Q = 15 M
2	2	5 M x 5 Q = 25	3 M x 5 Q = 15 M

Each question will have five sub questions a, b, c, d, e and out of which any three should be answered.

Evaluation pattern: Practical

- Continuous Assessment for 50 Marks throughout the entire semester.
- 50 Marks Evaluation as per the following rubrics

Core Course	CIE	Journal	Total
I	20M	5M	25M
II	20M	5M	25M

10. Program and Course Code Format

The course is coded according to following criteria:

1. First two numbers in each course code indicates year of implementation of syllabus (23- year of implementation is 2023-24)
2. Third letter 'U' designates undergraduate
3. Fourth letter 'S' designate Science discipline and the digit followed is for semester number (S1 – 1st Semester)
4. Letter 'MT' is for Mathematics discipline (MT =Mathematics). This forms the programme code 23USMT. For the further course codes programme code is amended as follows
5. To represent Major Core Course (MJ) followed by course number digit (1/2/3/4) and three lettered code representing the title of the course.
6. To represent Minor Stream Course (MN) followed by course number digit (1/2/3/4) and three lettered code representing the title of the course.
7. For Ability enhancement course code, (AEC) alphabets followed by a digit (1/2) followed by 'EVS'-Environmental science are used.
8. For Value Added course code, (VEC) alphabets followed by a digit (1/2) followed by 'EVS'-Environmental science are used.
9. For Indian Knowledge System course code, (IKS) alphabets followed by a digit (1/2) followed by 'ICH'- Indian Cultural Heritage is used.

10. For Co-curricular course code, (CC) alphabets followed by a digit (1/2).
11. For Open Elective course code, (OE) alphabets followed by a digit (1/2).
12. 'P' followed by digit indicates practical course number. (Practical course number will be added for semesters only where there is more than one course.