Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

GLA University, Mathura

(NAAC Accredited 'A+' Grade)

NEP-2020 Based
Curriculum and Syllabi
of

B. Sc. Mathematics/
B. Sc. Mathematics (Hons. / Hons. with Research)

With
Specialization in Data Science

(w. e. f. Session 2024-2025)

DEPARTMENT OF MATHEMATICS
Institute of Applied Sciences and Humanities

Approved by	:	BOS	Academic Council	Executive Council
Approval Status	:	✓	✓	✓
Approval Date	:	06.07.2023	22.07.2023	05.08.2023

TABLE OF CONTENTS

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

1. VISION AND MISSION

Vision and Mission of the University

Vision

We envision ourselves as a pace-setting university of Academic Excellence focused on education, research and development in established and emerging professions.

Mission

M1: To impart quality professional education, to conduct commendable research and to provide credible consultancy and extension services as per current and emerging socio-economic needs.

M2: To continuously enhance and enrich the teaching/learning process and set such standards, education and otherwise, that other institutes would want to emulate.

M3: To be totally student-centric, thus promoting the overall growth and development of intellect and personality of our prime stakeholders, namely students, so that our alumni are worthy citizens and highly sought-after professionals worldwide.

M4: To empower the members of faculty and staff so that the university's ambience is one of harmony, mutual respect, cooperative endeavour and receptivity towards positive ideas.

M5: To proactively seek regular feedback from all the stakeholders and take appropriate measures based on them thus leading to excellent learning process. Be totally student-centric, thus promoting the overall growth and development of intellect and personality of our prime stakeholders, namely students, so that our alumni are worthy citizens and highly sought-after professionals worldwide.

Vision and Mission of the Department

Vision

The department aims to be a center of excellence in Mathematics, computing and is vigorously engaged in both research and teaching.

Mission

M1: To perform widely recognized research in focused areas of mathematical and statistical theory, methodology, and education.

M2: To explore applications of Mathematics and Statistics and engage in collaborative research in an interdisciplinary environment.

M3: To discover, mentor, and nurture mathematically inclined students, and provide them a supportive environment that fosters intellectual growth.

M4: To prepare our postgraduate students to develop the attitude and ability to apply mathematical methods and ideas in a wide variety of careers.

M5: To provide professional services based on our diverse mathematical and statistical expertise to the scientific, technical, and educational community.

2. BACKGROUND

i) National Educational Policy (NEP) - 2020

The National Education Policy 2020 lays emphasis on making the education more holistic and effective by integration of general (academic) and vocational education while ensuring the vertical and horizontal mobility of students and learners between academic and vocational streams. Built on the foundational pillars of access, equity, quality, affordability and accountability, NEP strives to transform India into a vibrant knowledge society to become a global knowledge superpower.

The NCrF (National Credit Framework) relies on an integrating approach across the education and skilling frameworks enabling the education and skilling eco-system in implementing one single credit – based framework in line with the vision of NEP 2020. While catering to multi-disciplinarily and holistic education across sciences, social sciences, arts, humanities and sports, NCrF enables multiple entry-multiple exit pathways in general and vocational education; ensures flexibility for students to choose their learning trejectories and career choices, including option for mid-way course correction or modification as per their talents and intrests.

The NEP 2020 also recommended to establish an **'Academic Bank of Credit (ABC)'** and **'Academic Bank for College and University Students of Uttar Pradesh (ABACUS-UP)'** which could digitally store the academic credits earned from recognized institutions so that the degrees can be awarded considering credits earned.

The curricular reforms are instrumental for the desired learning outcomes. In view of this, the Department of Mathematics of Institite of Applied Sciences and Humanities of GLA University, Mathura, U. P. took initiative to propose the curriculum of its undergraduate program in alignment with National Education Policy-2020. The key features of the policy were discussed in the meeting of heads of various departments with the hon'ble Vice Chancellor and the action plan was made with well-defined responsibilities and timeline for academic reforms.

The process of finalizing the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the policy, enabling them to propose the curriculum in sync with the policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to incorporate the vital aspects of the policy in the revised curriculum focused on creating holistic and innovative individuals equipped with the key skills for the development of an enlightened, socially conscious, skilled and self-sustained nation.

The curricula articulate the spirit of the policy by emphasizing upon—integrated approach to learning; innovative pedagogy and assessment strategies; multidisciplinary education; critical

thinking; ethical values; entrepreneurial and professional skills; social, moral and environmental awareness; holistic, discussion-based, and analytical learning; flexibility in choice of courses; student-centric participatory learning; offering multiple entry and exit points; integration of extra-curricular and curricular aspects; closer collaborations between industry and higher education institutions for science programs; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each program.

The curricula of UG program could be devised with efforts of the faculty and head of the department. The draft prepared by the department was discussed in a series of discussion sessions conducted at department and the University level. The Dean, Academic affairs of the University conducted a series of meetings with Heads and Deans to deliberate upon the parameters of the curriculum to formulate a uniform template featuring background, Programme Outcomes (POs), Programme Specific Outcomes (PSOs), Structure of Bachelor's Course, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process. The experts of the Board of Studies contributed to a large extent in giving the final shape to the curriculum.

Advantages of National Credit Framework:

- Establishing equivalence between general and vocational education and training / skilling.
- Mobility between and within general and vocational education and training / skilling.
- Enabling provisions for lifelong learning through multiple entry and multiple exit options.
- Integration and intermingling of education, skilling and work experience.
- Enabling creditization of learning for students with varying learning capacities.

ii) About Mathematics

Mathematics is a vital tool for global knowledge and communication that organizes and prevents chaos in our life. Mathematics aids in our understanding of the world and is a good tool for developing mental discipline. Logical reasoning, critical thinking, creative thinking, abstract or spatial thinking, problem-solving abilities, and even effective communication skills are all fostered by Mathematics. Mathematics is required to know all other fields of sciences. In one way or another, they all rely on mathematics. The scale of mathematics influences the discipline and mastery of any other science or art.

iii) About the programme

(a) **Objectives:** With the continuous advances in technology, large quantities of data are being collected, stored, and efficiently managed, but to analyse them and discover hidden information, the foundation of Mathematics, Statistics, and Data Science is imperative. The Department of Mathematics at GLA University offers a Bachelor of Science (B.Sc.) degree in Mathematics of 3 years and a B.Sc. (Hons. / Hons. with Research) degree in Mathematics of 4 years with a specialization in Data Science. It is an interdisciplinary programme, an amalgamation of the fields of Mathematics and Data Science. It is designed specially to build up a strong foundation in Mathematics to enhance analytical and computational skills of the students.

(b) Duration: B.Sc. Mathematics with specialization in Data Science is a full time under graduate level program offered by the Department of Mathematics. This is a 3 year degree program, consisting of six semesters with two semesters per year. However, it can be extended to 4 year degree program if a student chooses to continue for the Hons. / Hons. with Research Degree in the same program.

(c) Eligibility:

- The candidate must have achieved at least 50% marks in 10+2 with Mathematics
- A Valid GLAET score

(d) Four Year UG Degree (Hons.):

A four year UG Hons. Degree in the major discipline will be awarded to those who complete a four-year degree program with 160 credits and have satisfied the credit requirements as per CBCS.

(e) Four Year UG Degree (Hons. with Research):

Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation (major discipline) under the guidance of faculty member of the University.

iv) Qualification Descriptors (Possible Career Pathways)

Scope of Employability

After successfully completing the course, the students receive a bachelor degree in Mathematics with specialization in Data Science. Upon completion of this course, the students will be able to further extend their research in Mathematics. They will also be expected to develop life skills in addition to mathematical ability, as are required to have a wealthy life.

The following career paths possibly open up as a result of pursuing an undergraduate degree in Mathematics:

1. **Data Analyst/Scientist**
2. **Statistical Analyst**
3. **Computational Analyst**
4. **Mathematical Analyst/Modeller**
5. **Research Analyst/Scientist**
6. **Government Jobs**
7. **Teaching**
8. **Research**
9. **Chartered Accountancy**
10. **Banking**

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

3. PROGRAMME OUTCOMES (POs)

Students enrolled in the Bachelor's Program offered by the Departments of Mathematics under Institute of Applied Sciences and Humanities will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

PO No.	PROGRAMME OUTCOMES (POs)
PO 1	**Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.
PO 2	**Problem Solving**: Understand and solve problems of relevance to society to meet the specified needs using the knowledge, skills, and attitudes acquired from humanities/sciences/ mathematics/social sciences.
PO 3	**Effective Communication**: Speak, read, write, listen clearly in person and through electronic media in English and one Indian language, and make meaning of the world by connecting people, ideas, books, media, and technology.
PO 4	**Individual and Teamwork:** Function effectively as an individual and as a member or leader in diverse teams and a wide variety of settings.
PO 5	**Ethics**: Understand multiple value systems, including your own, the moral dimensions of your decisions, and accept responsibility for them.
PO 6	**Environment and sustainability**: Understand the impact of technology and business practices in societal and environmental contexts and sustainable development.
PO 7	**Self-directed and life-long learning:** Demonstrate the ability to engage in independent and life-long learning in the broadest context socio-technological changes.
PO 8	**Design Mindset:** Represent and develop tasks and work processes for desired outcomes.
PO 9	**Computational Thinking:** Understand data-based reasoning through the translation of data into abstract concepts using computing technology-based tools.
PO 10	**Effective Citizenship:** Demonstrate empathetic social concern and equity-centered national development and act with an informed awareness of issues and participate in civic life through volunteering.

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

4. PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO 1	Understand the foundations of mathematics and the importance of logic.
PSO 2	Solve problems of physics using differential equations and vector algebra
PSO 3	Solve problems in algebra, analysis and numerical analysis.
PSO 4	Translate real world problems into mathematical models.

5. STRUCTURE OF BACHELOR PROGRAM

Types of Courses	**Nature**	**Total Credits**	**%**
Program Core Courses (C)	Major Courses as per common minimum syllabus	59	35.5
	Major Courses offered by same faculty	16	9.6
	Minor Courses offered by other department	32	19.27
Elective Courses (E)	Discipline Specific Elective Courses	5+12*	3/7.2
Multidisciplinary Courses (MDC)	Compulsory Courses	9	5.4
Ability Enhancement Courses (AEC)	Compulsory Courses	8	4.8
Skill Enhancement Courses (SEC)	Compulsory Courses	9	5.4
Value Added Courses (VAC)	Co-curricular / compulsory subjects (to be chosen from the list of subjects)	12	7.2
Summer Internship (SIP)	Compulsory	4	2.4
Project (J)	Compulsory in 4- year Bachelor's degree (Hons. with Research)	12*	7.2
Total		**166**	**100%**

Note: The Scheme and Syllabus of the programme are subject to change as per the UGC guidelines, National Education Policy (NEP-2020) and University ordinance.

B. Sc. (Mathematics) / B. Sc. Mathematics (Hons./By Research) with Specialization in Data Science

Course Structure

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Sem</th><th colspan="2">Major as per common minimum syllabus</th><th>Minor offered by other department of same faculty</th><th>Multidisciplinary by other faculty</th><th>AEC (Humanities Department)</th><th>SEC (Skill Enhancement Compulsory)</th><th>VAC Subjects available on UP Govt. Website</th><th>SIP after II Year</th><th>Project</th><th rowspan="2">Total</th><th>NCRF</th><th>Credit Earned</th></tr>
<tr><th>Major 1</th><th>Major 2 (4 Credit)</th><th>Minor</th><th>Multi-disciplinary (3 Credit)</th><th>AEC (4 Credit)</th><th>SEC (3 Credit)</th><th>VAC (2 Cr)</th><th>SIP</th><th>Project</th><th>Credit Level</th><th></th></tr>
<tr><td rowspan="3">1</td><td rowspan="2">I</td><td>Differential Calculus and Integral Calculus (4 Cr)</td><td rowspan="2">Statistics for Data Science-I (4 Cr)</td><td>Data Science-I (3 Cr) (offered by CEA Dept.)</td><td rowspan="2"></td><td rowspan="2">Language Skills-I (2 Cr) (offered by English Dept.)</td><td rowspan="2">R-Programming Lab (3 Cr)</td><td rowspan="2">Food, Nutrition and Hygiene (2 Cr)</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">40</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Practical (2 Cr)</td><td>Data Science-I Lab (1 Cr) (offered by CEA Dept.)</td></tr>
<tr><td>II</td><td>Matrices and Differential Equations and Geometry (6 Cr)</td><td></td><td>Database Management System (3 Cr) (offered by CEA Dept.)
Database Management System Lab (1 Cr) (offered by CEA Dept.)
Programming Logic using Python (3 Cr) (offered by CEA Dept.)
Python Programming Lab (1 Cr) (offered by CEA Dept.)</td><td>Project Management (3 Cr)
(offered by IBM)</td><td>Language Skills-II (2 Cr) (offered by English Dept.)</td><td></td><td>Human Values and Environment Studies (2 Cr)</td></tr>
<tr><td colspan="11">Students who opt to exit after completion of first year and have secured 40 credits will be awarded a UG certificate if, in addition, they complete Vocational course (Skill Oriented) of 4 credits during summer vacation of first year</td><td>4.5</td><td>40+4</td></tr>
<tr><td rowspan="3">2</td><td>III</td><td>Algebra and Mathematical Methods (6 Cr)</td><td>Statistics for Data Science-II (4 Cr)</td><td>Data Science- II (3 Cr) (offered by CEA Dept.)
Data Science- II Lab (1 Cr) (offered by CEA Dept.)</td><td></td><td>English for Specific Purposes (2 Cr) (offered by English Dept.)</td><td>Applications of MS Excel (3 Cr) (offered by IBM)</td><td>First Aid and Health (2 Cr)</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">40</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>IV</td><td>Differential Equation and Mechanics (6 Cr)</td><td></td><td>Data Visualization using Python (3 Cr) (offered by CEA Dept.)
Data Visualization Lab using Python (1 Cr) (offered by CEA Dept.)
Research Methodology (4 Cr) (offered by IBM)</td><td>Product Design and Development (3 Cr) (offered by ME Dept.)</td><td>Professional Communication (2 Cr) (offered by English Dept.)</td><td></td><td>Physical Education and Yoga (2 Cr)</td></tr>
<tr><td colspan="11">Students who opt to exit after completion of second year and have secured 80 credits will be awarded a UG Diploma if, in addition, they complete Vocational course (Skill Oriented) of 4 credits during summer vacation of first/ second year</td><td>5</td><td>80+4</td></tr>
<tr><td rowspan="4">3</td><td rowspan="3">V</td><td>Group Ring Theory and Linear Algebra (5 Cr)</td><td rowspan="3">Multivariate Statistics (4 Cr)</td><td rowspan="3"></td><td rowspan="3">Econometrics (3 Cr) (offered by Economics Dept.)/
Cyber Ethics & Laws (3 Cr) (offered by CEA Dept.)/
Satellite Communication and Remote Sensing (3 Cr) (offered by Physics Dept.)</td><td rowspan="4"></td><td rowspan="3"></td><td rowspan="3">Analytic Ability and Digital Awareness (2 Cr)</td><td rowspan="4">SIP (4 Cr)</td><td rowspan="4"></td><td rowspan="4">40</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>Any one of the following (5 Credit):
1. Number Theory and Game Theory
2. Graph Theory and Discrete Mathematics
3. Differential Geometry & Tensor Analysis</td></tr>
<tr><td>VI</td><td>Metric Space and Complex Analysis (4 Credit)
Numerical Analysis and Operations Research (4 Credit)
Practical (2 Cr)</td><td>Time Series and Stochastic Processes (4 Cr)</td><td></td><td></td><td>Statistical Computation and Simulation (4 Cr)</td><td>Communication Skills and Personality Development (2 Cr)</td></tr>
<tr><td colspan="11">Students who with to go for 3 year UG program will be awarded UG Degree in major discipline after successful completion of three years, securing 120 credits and satisfying the minimum credit requirement as per CBCS</td><td>5.5</td><td>120</td></tr>
</table>

4	VII	Real Analysis (5 Cr) Ordinary Differential Equations (5 Cr)	3**	Data Structures and Algorithms (3 Cr) **(offered by CEA Dept.)** Data Structures and Algorithms Lab (1 Cr) **(offered by CEA Dept.)**							40		
	VIII	Topology (5 Cr) Functional Analysis (5 Cr)		Cryptography and Network Security (3 Cr) **(offered by CEA Dept.)** Cryptography and Network Security Lab (1 Cr) **(offered by CEA Dept.)**						12 Cr			
Four Year UG Degree (Honors): A four year UG Honors Degree in the major discipline will be awarded to those who complete a four year degree program with 160 credits and have satisfied the credit requirements as per CBCS												6	160
*Four Year UG Degree (Honors with research): Students who secure 75% marks and above in the first six semester and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. they should do a research project or dissertation (major discipline) under the guidance of faculty member of the university.													

** Honors students those are not taking research need to take 3 courses of 12 credits from the following:

S. No.	Name of Subject	Offered By
1	Soft Computing	CEA Dept.
2	Introduction to Big Data Analytics	CEA Dept.
3	Big Data Analytics Lab	CEA Dept.
4	Cloud Computing	CEA Dept.
5	Cloud Computing Lab	CEA Dept.
6	Mathematical Modelling	Maths Dept.
7	Operational Research-I	Maths Dept.
8	Regression Analysis and Predictive Modelling	Maths Dept.
9	Coding Theory	Maths Dept.

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

Course Type

Program Core Courses (C)

1. Major Courses as per common minimum syllabus
2. Major Courses offered by same faculty
3. Minor Courses offered by other department of same faculty

Elective Courses (E)
Multidisciplinary Courses (MDC)
Ability Enhancement Courses (AEC)
Skill Enhancement Compulsory Courses (SEC)
Value Added Courses (VAC)
Summer Internship (SIP)
Project (J)

Total Credits: 160, Year-wise distribution of credits: 40+ 40 + 40 + 40

PROGRAM CORE COURSES (C)

1. Major Courses as per common minimum syllabus

S. No.	Sem.	Course Code	Course Title	L	T	P	J	Credit
1	I	BMAC 0001	Differential Calculus and Integral Calculus	3	1	0	0	4
2	I	BMAC 0801	Practical	0	0	4	0	2
3	II	BMAC 0002	Matrices and Differential Equations and Geometry	5	1	0	0	6
4	III	BMAC 0003	Algebra and Mathematical Methods	5	1	0	0	6
5	IV	BMAC 0004	Differential Equation and Mechanics	5	1	0	0	6
6	V	BMAC 0005	Group Ring Theory and Linear Algebra	4	1	0	0	5
7	VI	BMAC 0006	Metric Space and Complex Analysis	3	1	0	0	4
8	VI	BMAC 0007	Numerical Analysis and Operations Research	3	1	0	0	4
9	VI	BMAC 0802	Practical	0	0	4	0	2
10	VII	BMAC 0008	Real Analysis	4	1	0	0	5
11	VII	BMAC 0009	Ordinary Differential Equations	4	1	0	0	5
12	VIII	BMAC 0010	Topology	4	1	0	0	5
13	VIII	BMAC 0011	Functional Analysis	4	1	0	0	5

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

PROGRAM CORE COURSES (C)

2. Major Courses offered by same faculty

S. No.	Sem.	Course Code	Course Title	L	T	P	J	Credit
1	I	BMAC 0101	Statistics for Data Science-I	3	1	0	0	4
2	III	BMAC 0102	Statistics for Data Science-II	3	1	0	0	4
3	V	BMAC 0103	Multivariate Statistics	3	1	0	0	4
4	VI	BMAC 0104	Time Series and Stochastic Processes	3	1	0	0	4

3. Minor Courses offered by other department of same faculty

S. No.	Sem.	Course Code	Course Title	Offering Dept.	L	T	P	J	Credit
1	I	BCAC 0102	Data Science-I	CEA	3	0	0	0	3
2	I	BCAC 0182	Data Science-I Lab	CEA	0	0	2	0	1
3	II	MCAC 0009	Database Management System	CEA	3	0	0	0	3
4	II	MCAC 0807	Database Management System Lab	CEA	0	0	2	0	1
5	II	BCAE 0003	Programming Logic using Python	CEA	3	0	0	0	3
6	II	BCAE 0809	Python Programming Lab	CEA	0	0	2	0	1
7	III		Data Science-II	CEA	3	0	0	0	3
8	III		Data Science-II Lab	CEA	0	0	2	0	1
9	IV		Data Visualization using Python	CEA	3	0	0	0	3
10	IV		Data Visualization Lab using Python	CEA	0	0	2	0	1
11	IV		Research Methodology	IBM	3	1	0	0	4
12	VII		Data Structures and Algorithms	CEA	3	0	0	0	3
13	VII		Data Structures and Algorithms Lab	CEA	0	0	2	0	1
14	VIII		Cryptography and Network Security	CEA	3	0	0	0	3
15	VIII		Cryptography and Network Security Lab	CEA	0	0	2	0	1

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

ELECTIVE COURSES (E) [any ONE]

1. Major Courses as per common minimum syllabus

S. No.	Sem.	Course Code	Course Title	L	T	P	J	Credit
1	V	BMAE 0001	Number Theory and Game Theory	4	1	0	0	5
2	V	BMAE 0002	Graph Theory and Discrete Mathematics	4	1	0	0	5
3	V	BMAE 0003	Differential Geometry & Tensor Analysis	4	1	0	0	5

2. Major Courses offered by same faculty

S. No.	Sem.	Course Code	Course Title	Offering Dept.	L	T	P	J	Credit
1	VII		Soft Computing	CEA	3	1	0	0	4
2	VII		Introduction to Big Data Analytics	CEA	3	0	0	0	3
3	VII		Big Data Analytics Lab	CEA	0	0	2	0	1
4	VII		Cloud Computing	CEA	3	0	0	0	3
5	VII		Cloud Computing Lab	CEA	0	0	2	0	1
6	VII	BMAE 0004	Mathematical Modelling	Maths	3	1	0	0	4
7	VII	BMAE 0005	Operational Research-I	Maths	3	1	0	0	4
8	VII	BMAE 0006	Regression Analysis and Predictive Modelling	Maths	3	1	0	0	4
9	VII	BMAE 0007	Coding Theory	Maths	3	1	0	0	4

Multi disciplinary Courses (MDC)

1. Courses offered by other faculty

S. No.	Sem.	Course Code	Course Title	Offering Department	L	T	P	J	Credit
1	II	BBAO 8004	Project Management	IBM	3	0	0	0	3
2	IV		Product Design and Developement	ME	3	0	0	0	3
3	V		Econometrics/ Cyber Ethics & Laws/ Satellite Communication and Remote Sensing	Economics/ CEA/ Physics	3	0	0	0	3

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

Ability Enhancement Course (AEC)

S. No.	Sem.	Course Code	Course Title	Offering Department	L	T	P	J	Credit
1	I	BELA 0003	Language Skills-I	English	2	0	0	0	2
2	II	BELA 0004	Language Skills-II	English	2	0	0	0	2
3	III		English for Specific Purposes	English	2	0	0	0	2
4	IV		Professional Communication	English	2	0	0	0	2

Skill Enhancement Courses (SEC)

S. No.	Sem.	Course Code	Course Title	Offering Dept.	L	T	P	J	Credit
1	I	BMAK 0801	R-Programming Lab	Mathematics	0	0	6	0	3
2	III		Applications of MS Excel	IBM	3	0	0	0	3
3	VI	BMAK 0101	Statistical Computation and Simulation	Mathematics	3	0	0	0	3

Value Added Courses (VAC)

S. No.	Sem.	Course Code	Course Title	Offering Department	L	T	P	J	Credit
1	I	BCHO 0011	Food, Nutrition and Hygiene	Chemistry	2	0	0	0	2
2	II	BCHO 0012	Human Values and Environment Studies	Chemistry and English	2	0	0	0	2
3	III		First Aid and Health	IPR	2	0	0	0	2
4	IV		Physical Education and Yoga	Education	2	0	0	0	2
5	V		Analytic Ability and Digital Awareness	T & D	2	0	0	0	2
6	VI		Communication Skills and Personality Development	T & D	2	0	0	0	2

Project (J)

S. No.	Sem.	Course Code	Course Title	L	T	P	J	Credit
1	VIII		Project	0	0	0	12	12

Online Course Credit Transfer:

Courses other than major and minor may be done through online platforms like **SWAYAM** / **NPTEL** / other approved platforms by the University. The online courses should have similar course content as mentioned in the course structure of the particular program. The same credits will be transferred in the credit bank of the student.

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

Elective Courses

(Offered by Mathematics department to other departments)

Minor Courses

S. No.	Course Code	Course Title	L	T	P	J	Credit
1	BMAE 0101	Algebra and Calculus	3	1	0	0	4
2	BMAS 0505	Statistics and Numerical Methods	3	1	0	0	4
3		Partial Differential Equations and Integral Transforms	3	1	0	0	4
4		Operations Research	3	1	0	0	4
5	BMAE 0111	Mathematics I	3	1	0	0	4
6	BMAE 0112	Mathematics II	3	1	0	0	4

Multidisciplinary Courses

S. No.	Course Code	Course Title	L	T	P	J	Credit
1	MMAS 0501	Advanced Biostatistics	3	0	0	0	3
2	BMAS 0203	Business Mathematics	3	0	0	0	3
3	BMAS 0204	Business Statistics	3	0	0	0	3

Skill Enhancement Courses

S. No.	Course Code	Course Title	L	T	P	J	Credit
1	BMAK 0801	R-Programming Lab	2	0	2	0	3
2	BMAK 0101	Statistical Computation and Simulation	3	0	0	0	3

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

5. SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

SEMESTER-I

Total Credits: 21 (Major C: 10, Minor C: 4, AEC: 2, SEC: 3, VAC: 2)

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0001	Differential Calculus and Integral Calculus	3	1	0	0	4	4
2	2	BMAC 0801	Practical	0	0	4	0	2	2
3	3	BMAC 0101	Statistics for Data Science-I	3	1	0	0	4	4
Minor Core Courses (C)									
4	1	BCAC 0102	Data Science-I **(offered by CEA Dept.)**	3	0	0	0	3	3
5	2	BCAC 0182	Data Science-I Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
Ability Enhancement Course (AEC)									
6	1	BELA 0003	Language Skills-I **(offered by English Dept.)**	2	0	0	0	2	2
Skill Enhancement Courses (SEC)									
7	1	BMAK 0801	R-Programming Lab	2	0	2	0	4	3
Value Added Courses (VAC) [from the list given on page no. 15]									
8	1	BCHO 0011	Food, Nutrition and Hygiene **(offered by Chemistry Dept.)**	2	0	0	0	2	2

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

SEMESTER-II*

Total Credits: 21 (Major C: 6, Minor C: 8, MDC: 3, AEC: 2, VAC: 2)

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0002	Matrices and Differential Equations and Geometry	5	1	0	0	6	6
Minor Core Courses (C)									
2	1	MCAC 0009	Database Management System **(offered by CEA Dept.)**	3	0	0	0	3	3
3	2	MCAC 0807	Database Management System Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
4	3	BCAE 0003	Programming Logic using Python **(offered by CEA Dept.)**	3	0	0	0	3	3
5	4	BCAE 0809	Python Programming Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
Multi disciplinary Courses (MDC)									
6	1	BBAO 8004	Project Management **(offered by IBM)**	3	0	0	0	3	3
Ability Enhancement Course (AEC)									
7	1	BELA 0004	Language Skills-II **(offered by English Dept.)**	2	0	0	0	2	2
Value Added Courses (VAC) [from the list given on page no. 15]									
8	1	BCHO 0012	Human Values and Environment Studies **(Offered by Chemistry & English Depts.)**	2	0	0	0	2	2

***** The students who opt to exit after completion of I year (semester II) and have secured 40 credits will be awarded a **UG Certificate** if, inaddition, they complete vocational course (skill oriented) of 4 credits during summer vacation of I year.

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

SEMESTER-III

Total Credits: 21 (Major C: 10, Minor C: 4, AEC: 2, SEC: 3, VAC: 2)

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0003	Algebra and Mathematical Methods	5	1	0	0	6	6
2	2	BMAC 0102	Statistics for Data Science-II	3	1	0	0	4	4
Minor Core Courses (C)									
3	1		Data Science- II **(offered by CEA Dept.)**	3	0	0	0	3	3
4	2		Data Science- II Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
Ability Enhancement Course (AEC)									
5	1		English for Specific Purposes **(offered by English Dept.)**	2	0	0	0	2	2
Skill Enhancement Courses (SEC)									
6	1		Applications of MS Excel **(offered by IBM)**	3	0	0	0	3	3
Value Added Courses (VAC) [from the list given on page no. 15]									
7	1		First Aid and Health **(offered by IPR)**	2	0	0	0	2	2

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

SEMESTER-IV*

Total Credits: 21 (Major C: 6, Minor C: 8, MDC: 3, AEC: 2, VAC: 2)

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0004	Differential Equation and Mechanics	5	1	0	0	6	6
Minor Core Courses (C)									
2	1		Data Visualization using Python **(offered by CEA Dept.)**	3	0	0	0	3	3
3	2		Data Visualization Lab using Python **(offered by CEA Dept.)**	0	0	2	0	2	1
4	3		Research Methodology **(offered by IBM)**	3	1	0	0	4	4
Multi disciplinary Courses (MDC)									
5	1		Product Design and Development **(offered by ME Dept.)**	3	0	0	0	3	3
Ability Enhancement Course (AEC)									
6	1		Professional Communication **(offered by English Dept.)**	2	0	0	0	2	2
Value Added Courses (VAC) **[from the list given on page no. 15]**									
7	1		Physical Education and Yoga **(offered by Education Dept.)**	2	0	0	0	2	2

***** The students who opt to exit after completion of II year (sem. IV) and have secured 80 credits will be awarded a **UG Diploma** if, inaddition, they complete vocational course (skill oriented) of 4 credits during summer vacation of I year.

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

SEMESTER-V

Total Credits: 19 (Major C: 9, E: 5, MDC: 3, VAC: 2)

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0005	Group Ring Theory and Linear Algebra	4	1	0	0	5	5
2	2	BMAC 0103	Multivariate Statistics	3	1	0	0	4	4
Elective Courses (E) [Any ONE]									
3	1	BMAE 0001	Number Theory and Game Theory	4	1	0	0	5	5
	2	BMAE 0002	Graph Theory and Discrete Mathematics						
	3	BMAE 0003	Differential Geometry & Tensor Analysis						
Multi disciplinary Courses (MDC) [Any ONE]									
4	1		Econometrics **(offered by Economics Dept.)**	3	0	0	0	3	3
	2		Cyber Ethics & Laws **(offered by CEA Dept.)**						
	3		Satellite Communication and Remote Sensing **(offered by Physics Dept.)**						
Value Added Courses (VAC) [from the list given on page no. 15]									
5	1		Analytic Ability and Digital Awareness **(offered by T & D Dept.)**	2	0	0	0	2	2

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

SEMESTER-VI**

Total Credits: 19 (Major C: 14, SEC: 3, VAC: 2) + 4 (SIP: 4)**

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0006	Metric Space and Complex Analysis	3	1	0	0	4	4
2	2	BMAC 0007	Numerical Analysis and Operations Research	3	1	0	0	4	4
3	3	BMAC 0802	Practical	0	0	4	0	4	2
4	4	BMAC 0104	Time Series and Stochastic Processes	3	1	0	0	4	4
Skill Enhancement Courses (SEC)									
5	1	BMAK 0101	Statistical Computation and Simulation	3	0	0	0	3	3
Value Added Courses (VAC) [from the list given on page no. 15]									
6	1		Communication Skills and Personality Development **(offered by T & D Dept.)**	2	0	0	0	2	2

Summer Internship* (SIP)									
7	1		Summer Internship	0	0	0	4	-	4

*All students will undergo **Summer Internships (SIP)** / Apprenticeships of 4 credits in a firm, industry, or organization or training in labs with faculty and researchers in their own or other HEIs / research institutions during the summer term.

**** The students who wish to go for 3 year UG Program will be awarded **UG Degree** in major discipline after successful completion of three years, securing 120 credits and satisfying the minimum credit requirements as per CBCS.

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

SEMESTER-VII

Total Credits (for Hons. students **without** Research)**: 26 (Major C: 10, Minor C: 4, E: 12)**
Total Credits (for Hons. students **with** Research)**: 14 (Major C: 10, Minor C: 4)**

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0008	Real Analysis	4	1	0	0	5	5
2	2	BMAC 0009	Ordinary Differential Equations	4	1	0	0	5	5
Minor Core Courses (C)									
3	1		Data Structures and Algorithms **(offered by CEA Dept.)**	3	0	0	0	3	3
4	2		Data Structures and Algorithms Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
Elective Courses* (E) [any THREE]									
5A	1		Soft Computing **(offered by CEA Dept.)**	3	1	0	0	4	4
5B	2		Introduction to Big Data Analytics **(offered by CEA Dept.)**	3	0	0	0	3	3
5C	3		Big Data Analytics Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
5D	4		Cloud Computing **(offered by CEA Dept.)**	3	0	0	0	3	3
5E	5		Cloud Computing Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
5F	6	BMAE 0004	Mathematical Modelling	3	1	0	0	4	4
5G	7	BMAE 0005	Operational Research-I	3	1	0	0	4	4
5H	8	BMAE 0006	Regression Analysis and Predictive Modelling	3	1	0	0	4	4
5I	9	BMAE 0007	Coding Theory	3	1	0	0	4	4

*Hons. students who are not taking research need to take 3 courses of 12 credits.

Head of the Department
Mathematics
Institute of Applied Sciences & Humanities
GLA University, Mathura

SEMESTER-VIII

Total Credits (for Hons. students **without** Research)**: 14 (Major C: 10, Minor C: 4)**
Total Credits (for Hons. students **with** Research)**: 26 (Major C: 10, Minor C: 4, Project: 12)**

Sr. No.	Course No.	Course Code	Course Title	L	T	P	J	Hrs/Week	Total Credits
Major Core Courses (C)									
1	1	BMAC 0010	Topology	4	1	0	0	5	5
2	2	BMAC 0011	Functional Analysis	4	1	0	0	5	5
Minor Core Courses (C)									
3	1		Cryptography and Network Security **(offered by CEA Dept.)**	3	0	0	0	3	3
4	2		Cryptography and Network Security Lab **(offered by CEA Dept.)**	0	0	2	0	2	1
Project* (P)									
1	1		Project	0	0	0	12		12

*Hons. students who are taking research need to take up research project of 12 credits under the guidance of a faculty member. The students are expected to complete the Research Project in the 8th semester. The research outcomes of their project work may be published in peer-reviewed journals or presented in conferences / seminars or may be patended.

SYLLABI OF SUBJECTS

First Year Courses

1. COURSE-LEVEL LEARNING OUTCOMES

<table>
<tr><td colspan="2">Course No: 1</td><td colspan="4">Course Name: Differential Calculus & Integral Calculus</td><td colspan="4">Course Code: BMAC 0001</td></tr>
<tr><td colspan="2" rowspan="2">Batch:
2024-2028</td><td colspan="4" rowspan="2">Programme: B. Sc. Mathematics
(With specialization in Data Science)</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>J</td><td>Credits</td><td>Contact Hrs Per Week: 4</td></tr>
<tr><td>I</td><td>3</td><td>1</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 48</td></tr>
<tr><td colspan="4">Total Evaluation Marks: 100

Mid Term: 30 Marks
End Term: 50 Marks
Internal Assessment: 20 Marks</td><td colspan="6">Examination Duration:
Mid Term (2 hours), End Term (3 hours)
Pre-requisite of course: Nil
Nature of Course: Major Course as per common minimum syllabus</td></tr>
<tr><td>Course Objective</td><td colspan="9">This course will develop a profound understanding of sequences, sub-sequences, convergence and divergence of series, continuity and differentiability and expansion of a function. This will also make the students able to know partial differentiation and its applications along with tracing of curves. Further, a deep understanding of Riemann integral, improper integrals, multiple integrals, vector differentiation and integration will be developed in this course. This course focuses on employability and skill development aligned with all CO’s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="9">CO1: The programme outcome is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for developing enhanced quantitative skills and pursuing higher mathematics and research as well.
CO2: By the time students complete the course, they will have wide ranging application of the subject and have the knowledge of real valued functions such as sequence and series. They will also be able to know about convergence of sequence and series. Also, they have knowledge about curvature, envelope and evolutes and trace curve in polar, Cartesian as well as parametric curves.
CO3: The main objective of the course is to equip the student with necessary analytic and technical skills. By applying the principles of integral he learns to solve a variety of practical problems in science and engineering.
CO4: The student is equipped with standard concepts and tools at an intermediate to advance level that will serve him well towards taking more advance level course in Mathematics.</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td>Module No.</td><td colspan="8">Content</td><td>Hours</td></tr>
<tr><td>I</td><td colspan="8">[Course Outcome(s) No.: 1, 2 and 4]
Introduction to Indian Ancient Mathematics and Mathematicians.
Definition of a sequence, theorems on limits of sequences, bounded and monotonic sequences, Cauchy's convergence criterion, Cauchy sequence, limit superior and limit inferior of a sequence, subsequence,

Series of non-negative terms, convergence and divergence, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic test, de Morgan and Bertrand's tests, alternating series, Leibnitz's theorem, absolute and conditional convergence.

Successive differentiation, Leibnitz theorem, Maclaurin’s and Taylor’s series, Partial differentiation, Euler’s theorem on homogeneous function, Asymptotes, Curvature, Envelops and evolutes, Tests for concavity and convexity, Points of inflexion, Multiple points, Parametric representation of curves and tracing of parametric curves, Tracing of curves in Cartesian and Polar forms.</td><td>24</td></tr>
</table>

II	**[Course Outcome(s) No.: 1, 3 and 4]** Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Differentiation under the sign of Integration. Improper integrals, their classification and convergence, Comparison test, μ-test, Abel's test, Dirichlet's test, quotient test, Beta and Gamma functions. Multiple integrals, change of order of double integration, Dirichlet's theorem, Liouville's theorem for multiple integrals. Vector Differentiation, Gradient, Divergence and Curl, Normal on a surface, Directional Derivative, Vector Integration, Theorems of Gauss, Green, Stokes and related problems.	24

Text Books:

- R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 2000.
- S. Balachandra Rao & C.K. Shantha, Differential Calculus, New Age Publications, 1992.
- T.M. Apostol, Calculus (Vol. I & II), John Wiley & Sons Inc., 1967.
- Shanti Narayan & P.K. Mittal, Integral Calculus, S. Chand, 2005.
- H. Kishan, A. L. Pathak, S.K.S. Bhadauria, M. Sharma & V. Singh, Differential Calculus, RP Publications, 2021.
- H. Kishan, R. C. S. Chandel, R. K. Shrivastav & K.M. Agrawal, Integral Calculus and Vector Calculus, RP Publications, 2021.
- H. Anton, I. Birens & S. Davis, Calculus, John Wiley and Sons Inc., 2002.

Reference Books:

- Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2011.
- G.B. Thomas & R.L. Finney, Calculus, Pearson Education, 2007.
- Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.
- Course Books published in Hindi.

Course No: 2	**Course Name:** Practical							**Course Code:** BMAC 0801
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** I	**L** 0	**T** 0	**P** 4	**J** 0	**Credits** 2	**Contact Hrs Per Week: 2** **Total Hours: 24**
Total Evaluation Marks: 100 **Internal:** 50 Marks **External:** 40 Marks **Attendance**: 10 Marks		**Examination Duration:** End Term (2 hours) **Pre-requisite of course:** Nil **Nature of Course:** Major Course as per common minimum syllabus						

Course Objective	This lab aims to develop an understanding of plotting of graphs of various functions, polynomials and curves. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** The main objective of the course is to equip the student to plot different graphs and solve the different types of equations by plotting the graph using different computer software such as Mathematica /MATLAB /Maple /Scilab/Maxima etc. **CO2:** After completion of this course, student would be able to know the convergence of sequences through plotting, verify Bolzano-Weierstrass theorem through plotting the sequence, Cauchy's root test by plotting n^{th} root and ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term. **CO3:** Student would be able to plot complex numbers and their representations, Operations like addition, substraction, multiplication, division, modulus and graphical representation of polar form. **CO4:** Student would be able to perform following task of matrix as addition, multiplication, inverse, transpose, determinant, rank, Eigenvectors, Eigenvalues, characteristic equation and verification of the Cayley-Hamilton theorem, solving the systems of linear equations.

COURSE SYLLABUS

Module No.	Content	Hours
I	**Practical / Lab work to be performed in computer lab.** List of the practicals to be done using Mathematica / MATLAB /Maple /Scilab/Maxima etc. 1. Plotting the graphs of the following functions: (i) ax (ii) $[x]$ (greatest integer function) (iii) x^{2n} ; $n \in N$ (iv) x^{2n-1}; $n \in N$ (v) $\frac{1}{x^{2n-1}}$; $n \in N$ (vi) $\frac{1}{x^{2n}}$; $n \in N$ (vii) $\sqrt{ax+b}$, $\|ax + b\|, c \pm \|ax + b\|$ (viii) $\frac{\|x\|}{x}, sin(\frac{1}{x}), x\ sin(\frac{1}{x}), e^{x}, e^{-x}\ for\ x \neq 0$ (ix) $e^{ax+b}, \log(ax+b), \frac{1}{ax+b}, sin(ax+b), cos(ax+b), \|\sin(ax + b)\|,$ $\|\cos(ax + b)\|$. Observe and discuss the effect of changes in the real constants a and b on the graphs. (2) By plotting the graph, find the solution of the equation $x = e^{x}, x^{2} + 1 = e^{x}, 1 - x^{2} = e^{x}, x = \log_{10}(x), cos(x) = x,$ $sin(x) = x, cos(y) = cos(x), sin(y) = sin(x)\ etc$ (3) Plotting the graphs of polynomial of degree 2, 3, 4 and 5 and their first and second derivatives. (4) Sketching parametric curves, e.g. Trochoid, Cycloid, Epicycloid and Hypocycloid etc. (5) Tracing of conic in cartesian coordinates.	24

	(6) Graph of circular and hyperbolic functions. (7) Obtaining surface of revolution of curves. (8) Complex numbers and their representations, Operations like addition, Multiplication, Division, Modulus. Graphical representation of polar form. (9) Find numbers between two real numbers and plotting of finite and infinite subset of R (10) Matrix Operations: Addition, Multiplication, Inverse, Transpose, Determinant, Rank, Eigenvectors, Eigenvalues, Characteristic equation and verification of the Cayley-Hamilton theorem, Solving the systems of linear equations. (11) Study the convergence of sequences through plotting. (12) Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. (13) Study the convergence/divergence of infinite series by plotting their sequences of partial sum. (14) Cauchy's root test by plotting n^{th} root. (15) Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ terms.	

Text Books:

- R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 2000.
- T.M. Apostol, Calculus (Vol. I & II), John Wiley & Sons Inc., 1967.
- Shanti Narayan & P.K. Mittal, Integral Calculus, S. Chand, 2005.

Reference Books:

- Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2011.
- G.B. Thomas & R.L. Finney, Calculus, Pearson Education, 2007.
- Suggestive digital platforms web links: NPTEL/SWAYAM/MOOCS.

<table>
<tr><td colspan="2">Course No: 3</td><td colspan="3">Course Name: Statistics for Data Science-I</td><td colspan="5">Course Code: BMAC 0101</td></tr>
<tr><td rowspan="2">Batch:

2024-2028</td><td rowspan="2">Programme: B. Sc. Mathematics
(With specialization in Data Science)</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>J</td><td>Credits</td><td>Contact Hrs Per Week: 4</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>0</td><td>4</td><td>Total Hours: 40</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

Mid Term: 30 Marks
End Term: 50 Marks
Internal Assessment: 20 Marks</td><td colspan="5">Examination Duration:
Mid Term (2 hours), End Term (3 hours)
Pre-requisite of course: Nil
Nature of Course: Major- 2 Course</td></tr>
<tr><td>Course Objective</td><td colspan="7">This course will develop a profound understanding of level of measurement and representation of data, measures of central tendency and dispersion, nature of frequency distribution and fitting of polynomial curves. This will also make the students able to know about correlation and regression analysis of data, random variable and its properties. Further, a deep understanding of mathematical expectation, moment generating function and probability generating function will be developed in this course. This course focuses on employability and skill development aligned with all CO’s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">After studying these topics, the students will be able to:
CO1: Understand the basic concepts of statistical analysis, variables, data and measures of central tendency and dispersion.
CO2: Apply the methods to actual quantitative data and interpreting the results of the analysis.
CO3: Perform correlation and regression analysis of given data.
CO4: Learn the concept of probability and probability distribution, mass and density functions.
CO5: Measure the marginal and conditional distributions.
CO6: Calculate mathematical expectation, moment and probability generating functions.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Module No.</td><td colspan="6">Content</td><td>Hours</td></tr>
<tr><td>I</td><td colspan="6">[Course Outcome(s) No.: 1, 2, and 3]
Types of data and level of measurement-nominal, ordinal, interval and ratio, frequency distribution, diagrammatic and graphical representation. Measures of central tendency and dispersion. Computation of moments, Skewness & Kurtosis by the method of moments. Fitting of polynomial curves and curves reducible to polynomial form.
Correlation: Karl Pearson’s coefficient, Spearman’s rank correlation coefficient, Partial and Multiple (only two independent variables case) and Regression lines.</td><td>20</td></tr>
<tr><td>II</td><td colspan="6">[Course Outcome(s) No.: 4, 5 and 6]
Review of conditional probability and Bayes’ theorem.
Random variables, Probability mass function (pmf), Probability density function (pdf), Cumulative distribution function (cdf), Joint probability mass function, Joint probability density function, Joint probability distribution function, Marginal and conditional distribution, Transformation of one-dimensional variable. Mathematical Expectation, Moment generating function and probability generating function.</td><td>20</td></tr>
<tr><td colspan="8">Text Books:
➢ P. Mukhopadhyay, An Introduction to the Theory of Probability, World Scientific, 2012.
➢ S. C. Gupta & V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2014.

Reference Books:
➢ J. E. Freund, Mathematical Statistics, PHI, 2001.
➢ A. M. Goon, M. K. Gupta & B. Dasgupta, Fundamentals of Statistics, Vol I, World Press, 1991.
➢ C. E. Weatherburn, A first course of Mathematical statistics, Cambridge University Press, 1961.</td></tr>
</table>

Course No: 1	**Course Name:** Data Science – I **(Offered by CEA Department)**							**Course Code:** BCAC 0102
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** I	**L** 3	**T** 0	**P** 0	**J** 0	**Credits** 3	**Contact Hrs. Per Week:** 3 **Total Hours:** 40
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Nil **Nature of Course:** Minor Courses offered by other department of same faculty						

Course Objective	This course introduces and helps to understand and implement supervised learning techniques. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Explain the basic concepts, principles and challenges of supervised machine learning. **CO2:** Select and apply appropriate regression or classification algorithms to solve real-world problems using Python. **CO3:** Evaluate and compare the performance and accuracy of different supervised machine learning models using various metrics and techniques. **CO4:** Enhance their supervised machine learning models using ensemble methods such as bagging, boosting and stacking. **CO5:** Design and implement an end-to-end machine learning solution with supervised learning for a given problem domain.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** Introduction to supervised machine learning: What is it? why is it useful? what are the main challenges and applications? **Regression algorithms**: Linear regression, polynomial regression, ridge and lasso regression, logistic regression, etc. How to fit, evaluate and compare regression models. How to handle outliers, multicollinearity, overfitting and underfitting, Gradient descent for linear regression.	20
II	**[Course Outcome(s) No.: 3, 4 and 5]** **Classification algorithms**: Support vector machines (SVM), decision trees, random forests, k-nearest neighbors (kNN), naive Bayes classifier, etc. How to fit, evaluate and compare classification models. How to handle imbalanced data, feature selection, and performance metrics. **Ensemble methods**: What are they, how do they work, what are the benefits and drawbacks of using them? Bagging, boosting, stacking, etc. Popular ensemble algorithms such as adaBoost, XGBoost and CatBoost.	20

Text Book:

- Müller, C. Andreas, & S. Guido, Introduction to machine learning with Python: A Guide for Data Scientists, O'Reilly Media Inc., 2016.

Reference Book:

- S. Shalev-Shwartz, & S. Ben-David. Understanding machine learning: From theory to algorithms, Cambridge University Press, 2014.

<table>
<tr><td colspan="2">Course No: 2</td><td colspan="4">Course Name: Data Science – I Lab
(Offered by CEA Department)</td><td colspan="4">Course Code: BCAC 0182</td></tr>
<tr><td rowspan="2">Batch:

2024-2028</td><td rowspan="2">Programme: B. Sc. Mathematics
(With specialization in Data Science)</td><td rowspan="2">Semester:

I</td><td>L</td><td>T</td><td>P</td><td>J</td><td>Credits</td><td>Contact Hrs. Per Week: 2</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>0</td><td>1</td><td>Total Hours: 20</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

Internal: 50 Marks
External: 40 Marks
Attendance: 10 Marks</td><td colspan="5">Examination Duration: End Term (2 hours)

Pre-requisite of course: Nil

Nature of Course: Minor Courses offered by other department of same faculty</td></tr>
<tr><td>Course Objective</td><td colspan="7">This lab course introduces and helps to understand and implement supervised learning techniques. This course focuses on employability and skill development aligned with all CO’s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Use software packages for data analysis and visualization.
CO2: Apply machine learning for data analysis.
CO3: Build machine learning models.
CO4: Evaluate the performance of machine learning models.
CO5: Communicate the results of data analysis in a clear and concise manner.</td></tr>
<tr><td colspan="8">COURSE SYLLABUS</td></tr>
<tr><td>Module No.</td><td colspan="6">Content</td><td>Hours</td></tr>
<tr><td>I & II</td><td colspan="6">• Installation on tools and its basics
• Demonstrate simple linear regression.
• Demonstrate regularization in linear regression.
• Demonstrate multiple linear regression.
• Demonstrate gradient descent in linear regression.
• Demonstrate classification using logistic regression.
• Demonstrate classification using SVM.
• Demonstrate classification using Decision Tree.
• Demonstrate classification on kNN.
• Demonstrate classification using naïve Bayes Classifier.</td><td>20</td></tr>
<tr><td colspan="8">Text Book:
➢ Müller, C. Andreas, & S. Guido, Introduction to machine learning with Python: A Guide for Data Scientists, O’Reilly Media Inc., 2016.

Reference Book:
➢ S. Shalev-Shwartz, & S. Ben-David. Understanding machine learning: From theory to algorithms, Cambridge University Press, 2014.</td></tr>
</table>

Course No: 1	**Course Name:** Language Skills-I **(Offered by Department of English)**							**Course Code:** BELA 0003
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** I	**L** 2	**T** 0	**P** 0	**J** 0	**Credits** 2	**Contact Hrs. Per Week:** 2 **Total Hours:** 30
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Nil **Nature of Course:** AEC						

Course Objective	The objective of the course is to help students attain a basic proficiency in reading and written communication. The course focuses on learning English language through context, development of reading skills for correct comprehension of a text, and enhancement of writing skills by using appropriate language structures and suitable vocabulary. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Enhance their reading skills, **CO2:** Comprehend a text and answer the questions based on it, **CO3:** Enrich their vocabulary, and **CO4:** Express their ideas in writing in correct English.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 4]** **Introducing the course details and assessment structure** **Spoken Activity:** Introducing self, Talking about daily routine; talking about one's native place Reading for understanding the content and context and to identify certain language aspects as given below: **Text 1:** "An Island of Trees" by Ruskin Bond • **Sentence**: Types (Functional/Structural). **Parts of a sentence**: Subject/Predicate/Object/Compliment • **Identifying Parts of speech**: Based on Application in the prescribed text **Text 2: Essay:** "How should one read a book" by Virginia Woolf • **Subject -Verb Concord**: Agreement of number and person **Enhancing Word Power:** Homophones, homonyms and homographs (Word list will be given) **Reading Comprehension (Enabler):** Reading of a passage and its comprehension. **Writing Skill:** Application within university for various purposes.	14
II	**[Course Outcome(s) No.: 1, 3 and 4]** Reading for understanding the content and context and to identify certain language aspects as given below: **Text:** "Three Blind Men Describe an Elephant" by E Santhosh Kumar **Determiners**: Articles, Quantifiers, Distributives **Tense:** Present, Past and Future; various aspects of tenses and their usage based on aforesaid text. **Text:** "Selfitis- the obsessive need to post selfies- is a genuine mental disorder, say psychologists" by Sarah Knapton (An article published in The Telegraph, 15 December 2017, United Kingdom) **Voice:** Identification and transformation Writing complaint to authorities about social issues (power cut, traffic system, safety issues) **Vocabulary:** Antonyms/Synonyms (A list of selected words will be provided) **Story Review:** Characterization; language aspects; social impact; moral; theme **Theme based writing:** Describing relevant national/international issues, social issues	16

Text Books:

- R. Murphy, Intermediate English Grammar, Cambridge University Press, 1999.
- G. Leech, & J. Svartvik, A Communicative Grammar of English, Longman, 2003.
- M. Swan, Practical English Usage, OUP, 2016.
- J. C. Nesfield, English Grammar: Composition and Usage, Macmillan Publishers India, 2019.

Reference Books:

- A. S. Hornby, Advanced Learners' Dictionary of Current English, OUP, 2015.
- D. Jones, English Pronouncing Dictionary, Cambridge University Press, 2006.

<table>
<tr><td colspan="2">Course No: 1</td><td colspan="3">Course Name: R- Programming Lab</td><td colspan="6">Course Code: BMAK 0801</td></tr>
<tr><td colspan="2" rowspan="2">Batch:

2024-2028</td><td colspan="3" rowspan="2">Programme: B. Sc. Mathematics
(With specialization in Data Science)</td><td>Semester:</td><td>L</td><td>T</td><td>P</td><td>J</td><td>Credits</td><td>Contact Hrs Per Week: 4</td></tr>
<tr><td>I</td><td>2</td><td>0</td><td>2</td><td>0</td><td>3</td><td>Total Hours: 40</td></tr>
<tr><td colspan="4">Total Evaluation Marks: 100

Internal: 50 Marks
External: 40 Marks
Attendance: 10 Marks</td><td colspan="7">Examination Duration: End Term (2 hours)
Pre-requisite of course: Nil
Nature of Course: SEC</td></tr>
<tr><td colspan="2">Course Objective</td><td colspan="10">This lab aims to develop an understanding of R Studio and R environment, types of different data objects, importing and exporting data, looping in R and graphical visualization of data. This course focuses on employability and skill development aligned with all CO’s.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="10">After studying these topics, the students will be able to:
CO1: Install and use packages of R.
CO2: Understand types of different data objects.
CO3: Import and export data.
CO4: Write functions and looping in R.
CO5: Visualize the data graphically.
CO6: Generate random numbers.</td></tr>
<tr><td colspan="12">COURSE SYLLABUS</td></tr>
<tr><td>Module No.</td><td colspan="10">Content</td><td>Hours</td></tr>
<tr><td>I/II</td><td colspan="10">[Course Outcome(s) No.: 1, 2, 3, 4, 5 and 6]
Introduction to R, R Studio and R environment. Installing and using packages of R.
Types of different data objects: vectors, matrices, factors, arrays, lists and data frames.
Vector arithmetic, generating regular sequences, handling missing values, character vectors, indexing vectors, modes and attributes of objects.
Importing and exporting data. Combining different datasets, Operations on vectors and matrices, Writing functions and looping in R, Data manipulation and preprocessing.
Graphical visualisation of data: Histograms, box plot, stem-leaf, frequency polygon, pie chart, and ogive. Customization of plot settings, adding legends and text to a plot. Generating random numbers and sampling procedures.</td><td>40</td></tr>
</table>

Text Books:

- M. Gardener, Beginning R: The Statistical Programming Language, Wiley, 2012.
- W. J. Braun & D. J. Murdoch, A First Course in Statistical Programming with R, Cambridge University Press, 2007.

Reference Books:

- M. J. Crawley, Statistics: An Introduction Using R, Wiley, 2015.
- J. Albert & M. Rizzo, R by Examples, Springer, 2012.

Course No: 1	**Course Name:** Food, Nutrition and Hygiene **(Offered by Department of Chemistry)**							**Course Code:** BCHO 0011
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** I	**L** 2	**T** 0	**P** 0	**J** 0	**Credits** 2	**Contact Hrs. Per Week:** 2 **Total Hours:** 30
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Nil **Nature of Course:** VAC						

Course Objective	• To learn the basic concept of the Food and Nutrition • To study the nutritive requirement during special conditions like pregnancy and lactation • To learn meal planning • To learn 100 days' nutrition concept • To study common health issues in the society • To learn the special requirement of food during common illness • This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1: Remember:** Recall the definitions of food, nutrients, nutrition, health, and balanced diet. Also, remember the types of nutrition, including optimum nutrition, undernutrition, and over nutrition. **CO2: Apply:** (a) Apply knowledge of nutrients by understanding their sources, functions, and the effects of deficiency and excess for carbohydrates, fats, proteins, and minerals (such as calcium, phosphorus, sodium, potassium, iron, iodine, fluorine, and zinc). (b) Apply knowledge of vitamins, including water-soluble vitamins (B and C) and fat-soluble vitamins (A, D, E, and K). (c) Understand the importance of water and dietary fiber. **CO3: Analyze:** (a) Analyze the concept of nutrition during the first 1,000 days of life, including the requirements and factors affecting the growth of a child. (b)Evaluate additional nutrient requirements and risk factors during pregnancy. (c) Analyze the feeding practices during the stages of breast/formula feeding and complementary and early diet. **CO4: Evaluate:** Evaluate the relationship between common diseases prevalent in society and their nutritional requirements, focusing on diabetes, hypertension, obesity, constipation, diarrhea, and typhoid. Assess the national and international programs and policies aimed at improving dietary nutrition. **CO5: Create:** Create dietary plans and recommend specific immunity-boosting foods to enhance immune function and overall health.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** **Concept of Food and Nutrition** (a) Definition of Food, Nutrients, Nutrition, Health, balanced Diet (b) Types of Nutrition- Optimum Nutrition, under Nutrition, Over Nutrition (c) Meal planning- Concept and factors affecting Meal Planning (d) Food groups and functions of food **Nutrients: Macro and Micro** RDA, Sources, Functions, Deficiency and excess of	15

	(a) Carbohydrate, (b) Fats, (c) Protein, (d) Minerals Major: Calcium, Phosphorus, Sodium, Potassium Trace: Iron, Iodine, Fluorine, Zinc (e) Vitamins: Water soluble vitamins: Vitamin B, C Fat soluble vitamins: Vitamin A, D, E, K (f) Water, (g) Dietary Fiber	
II	**[Course Outcome(s) No.: 3, 4 and 5]** **1000 days Nutrition** (a) Concept, Requirement, Factors affecting growth of child (b) Prenatal Nutrition (0 - 280 days): Additional Nutrients' Requirement and risk factors during pregnancy (c) Breast / Formula Feeding (Birth – 6 months of age) Complementary and Early Diet (6 months – 2 years of age) **Community Health Concept** (a) Causes of common diseases prevalent in the society and Nutrition requirement in the following: Diabetes, Hypertension (High Blood Pressure), Obesity, Constipation, Diarrhea, Typhoid (b) National and International Program and Policies for improving Dietary Nutrition (c) Immunity Boosting Food	15

Text Books:

- A. Singh, Food and Nutrition, Star Publication, 2020.
- S. Sharma, Nutrition and Diet Therapy, Peepee Publishers, 2014.

Reference Books:

- 1000-Days-Nutrition_Brief_Brain-Think_Babies_FINAL.pdf
- https://pediatrics.aappublications.org/content/141/2/e20173716
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5750909/

Course No: 4	**Course Name:** Matrices and Differential Equations & Geometry						**Course Code:** BMAC 0002
Batch:	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:**	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week:** 6
2024-2028		II	5	1	0	0	6	**Total Hours:** 60

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Differential Calculus and Integral Calculus **Nature of Course:** Major Course as per common minimum syllabus

Course Objective	This course will develop a profound understanding of operations on matrices, Eigen values, Eigen vectors of a matrix, complex functions and its properties, formation and solution of ordinary differential equations of first and higher orders. This course will also provide the knowledge of three-dimensional coordinate geometry and its applications. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** The subjects of the course are designed in such a way that they focus on developing mathematical skills in algebra, calculus and analysis and give in depth knowledge of geometry, calculus, algebra and other theories. **CO2:** The student will be able to find the rank, eigen values of matrices and study the linear homogeneous and non-homogeneous equations. The course in differential equation intends to develop problem-solving skills for solving various types of differential equation and geometrical meaning of differential equation. **CO3:** The subjects learn and visualize the fundamental ideas about coordinate geometry and learn to describe some of the surface by using analytical geometry. **CO4:** On successful completion of the course, students have gained knowledge about regular geometrical figures and their properties. They have the foundation for higher course in Geometry.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2, and 3]** **Matrices:** Rank of a Matrix, Echelon form of a Matrix, Normal form of a Matrix, Inverse of a Matrix by elementary operations, System of linear homogeneous and non-homogeneous equations, Theorems on consistency of a system of linear equations. Eigen values, Eigen vectors and characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding inverse of a matrix. Complex functions and separation into real and imaginary parts, Exponential and Logarithmic functions, Inverse trigonometric and hyperbolic functions. **Geometry I**: General equation of second degree, System of conics, Tracing of conics, Confocal conics, Polar equation of conics and its properties. Three-dimensional coordinates, Projection and direction cosines, Plane and Straigtht line in three dimesnions.	30
II	**[Course Outcome(s) No.: 1, 3 and 4]** **Differential Equations**: Geometrical meaning of a differential equation, Equation of first order and first degree, Exact differential equations and equations reducible to the exact form. First order higher degree equations solvable for x, y, p; Clairaut's equation and singular solutions, Orthogonal trajectories, Linear differential equation of order greater than one with constant coefficients, Cauchy- Euler form, Simultaneous differential equations. **Geometry II**: Sphere, Cone and Cylinder. Central conicoids, Paraboloids, Plane section of conicoids, Generating lines, Confocal conicoids, Reduction of second degree equations.	30

Text Books:

- Stephen H. Friedberg, A.J Insel & L.E. Spence, Linear Algebra, Pearson, 2022.
- S.L. Loney, The Elements of Coordinate Geometry, McMillan, 2016.
- B. Rai, D.P. Choudhary & H. J. Freedman, A Course in Differential Equations, Narosa, 2002.
- H. Kishan, N. Swaroop & S. S. Shukla, Matrices and Differential Equations, RP Publications, 2022.
- S. P. Nigam, S. S. Gangwar & H. Kishan, Coordinate Geometry, RP Publications, 2022.
- R. S. Gupta & R. D. Pathak, Conic Sections, Pothishala Pvt. Ltd., 1998.

Reference Books:

- D.A. Murray, Introductory Course in Differential Equations, Orient Longman, 2017.
- Robert J.T Bell, Elementary Treatise on Coordinate Geometry of three dimensions, Macmillan, 1994.
- S.P. Nigam, S.S. Gangwar & H. Kishan, Coordinate Geometry, RP Publications, 2021.
- P.R. Vittal, Analytical Geometry 2D & 3D, Pearson, 2013.
- Suggested digital platform: NPTEL/SWAYAM/MOOCs
- Course Books published in Hindi

Course No: 3	**Course Name:** Database Management System **(Offered by CEA Department)**							**Course Code:** MCAC 0009
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** II	**L** 3	**T** 0	**P** 0	**J** 0	**Credits** 3	**Contact Hrs Per Week: 3** **Total Hours: 27**

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Nil

Course Objective	To acquire the knowledge of database design, data models and database languages and to study the physical and logical database designs, database modeling, relational, hierarchical, and network models. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After the completion of the course, the student will: **CO1:** Understand the basic concepts and the applications of database systems. **CO2:** Design ER Model and Relational Database Schema for real world application, given unambiguous problem statement. **CO3:** Implement SQL queries to access data, given relational database schema. **CO4:** Implement views, constrains and index, PL/SQL procedures and functions for a given scenario. **CO5:** Develop relational algebra expressions, given the relational database schema. **CO6:** Understand and apply database normalization principles. **CO7:** Describe the concepts of transaction and classification of database.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2, 3, 5 and 6]** **Introduction:** An Overview of Database Management System, Database System Vs File System, Database System Concept and Architecture, Data Model Schema and Instances, Data Independence, Database Language and Interfaces (DDL, DML, DCL), Database Development Life Cycle (DDLC) with Case Studies. **Data Modeling Using the Entity-Relationship Model:** ER Model Concepts, Notation for ER Diagram, Mapping Constraints, Keys, Specialization, Generalization, Aggregation, Reduction of an ER Diagram to Tables, Extended ER Model. **Relational Data Model and Language:** Relational Data Model Concepts, Integrity Constraints, Entity Integrity, Referential Integrity, Keys Constraints, Domain Constraints, Relational Algebra. **Database Design & Normalization I:** Functional Dependencies, Primary Key, Foreign Key, Candidate Key, Super Key, Normal Forms, First, Second, Third Normal Forms, BCNF, Non-Redundant Cover, Canonical Cover.	13
II	**[Course Outcome(s) No.: 3, 4, 6 and 7]** **Database Design & Normalization II:** 4th Normal Form, 5th Normal Form, Lossless Join Decompositions, MVD and JDs, Inclusion Dependence. **File Organization:** Indexing, Structure of Index files and types, Dense and Sparse Indexing. **Transaction Processing Concept:** Transaction System, Testing of Serializability, Serializability of Schedules, Conflict & View Serializable Schedule, Recoverability, Recovery from Transaction Failures, Log Based Recovery, Deadlock Handling. **Concurrency Control Techniques:** Concurrency Control, Locking Techniques for Concurrency Control, 2PL, Time Stamping Protocols for Concurrency Control, Validation Based Protocol. **Distributed Database:** Introduction of Distributed Database, Data Fragmentation and Replication.	14

Text Books:

- R. Elmasri & S. B. Navathe, Fundamentals of Database Systems, Pearson, 2010.

References Books:

- C. J. Date, An Introduction to Database Systems, Pearson, 1999.
- A. Silberschatz, H. Korth, S. Sudarshan, Database Systems Concepts, McGraw-Hill Education, 2005.
- B. C. Desai, An Introduction to Database Systems, Gagotia Publications, 2010.
- A. Majumdar & P. Bhattacharya, Database Management System, McGraw Hill Education, 2017.

<table>
<tr><td colspan="2">Course No: 4</td><td colspan="4">CourseName: Database Management System Lab
(Offered by CEA Department)</td><td colspan="4">Course Code: MCAC 0807</td></tr>
<tr><td colspan="2" rowspan="2">Batch:

2024-2028</td><td rowspan="2">Programme: B. Sc. Mathematics
(With specialization in Data Science)</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>J</td><td>Credits</td><td>Contact Hrs Per Week: 2</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>0</td><td>1</td><td>Total Hours:20</td></tr>
<tr><td colspan="4">Total Evaluation Marks: 100

Internal: 50 Marks
External: 40 Marks
Attendance: 10 Marks</td><td colspan="6">Examination Duration: End Term (2 hours)

Pre-requisite of course: Nil</td></tr>
<tr><td colspan="2">Course Objective</td><td colspan="8">To implement the concept of entity relationship approach and database languages. This course focuses on employability and skill development aligned with all CO’s.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="8">CO1: Apply SQL queries for DML and DDL.
CO2: Develop the SQL queries for real life scenarios.
CO3: Implement the procedural language (PL/SQL) and Triggers.</td></tr>
<tr><td colspan="10">COURSE SYLLABUS</td></tr>
<tr><td>Module No.</td><td colspan="8">Content</td><td>Hours</td></tr>
<tr><td>I / II</td><td colspan="8">• Introduction of Data Definition Language (DDL) and Its commands. (Create, Alter, Drop, Rename).
• Introduction of Data Manipulation Language (DML) and Its Commands (Insert, Update, Delete).
• Introduction of Transaction Control Language (T.C.L) &Data Control Language(D.C.L.)
• Creation, altering and dropping of tables and inserting rows into a table (use constraints while creating tables) examples using SELECT command.
• Queries using Aggregate functions (COUNT, SUM, AVG, MAX and MIN), GROUP BY, HAVING and Creation and dropping of Views.
• Queries using Conversion functions (to_char, to_number and to_date), string functions (Concatenation, lpad, rpad, ltrim, rtrim, lower, upper, initcap, length, substr and instr), date functions (Sysdate, next_day, add_months, last_day, months_between, least, greatest, trunc, round, to_char, to_date)
• To implement concept of Joins in SQL.
• To implement the concept of sub-queries.</td><td>20</td></tr>
<tr><td colspan="10">Text Books:
➢ R. Elmasri & S. B. Navathe, Fundamentals of Database Systems, Pearson, 2010.
➢ P. Sadalage, & M. Fowler, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Addison Wesley, 2012.

References Books:
➢ C. J. Date, An Introduction to Database Systems, Pearson, 1999.
➢ A. Silberschatz, H. Korth & S. Sudarshan, Database Systems Concepts, McGraw-Hill Education, 2010.
➢ E. Redmond & J. R. Wilson, Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement, O′Reilly, 2012.</td></tr>
</table>

Course No: 5	**Course Name:** Programming Logic Using Python **(Offered by CEA Department)**							**Course Code:** BCAE 0003
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** II	**L** 3	**T** 0	**P** 0	**J** 0	**Credits** 3	**Contact Hrs Per Week:** 3 **Total Hours:** 40

Total Evaluation Marks: 100	**Examination Duration:** Mid Term (2 hours), End Term (3 hours)
Mid Term: 30 Marks	**Pre-requisite of course:** NIL
End Term: 50 Marks **Internal Assessment**: 20 Marks	**Nature of Course:** Minor course offered by other department of same faculty

Course Objective	This course allows basic learning of syntax and semantics and functions in Python programming, construct data structure using OO concepts and its connectivity with database. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Identify the Python's data type - numbers, list, tuple, string, dictionary, class. **CO2:** Recognize Python syntax, semantics, and flow control –if else, for loop, while loop, and function. **CO3:** Apply the concepts of file handling and packages. **CO4:** Understand the basic concepts - abstraction, encapsulation, inheritance, and polymorphism of object-oriented programming. **CO5:** Describe the basic concepts of regular expressions. **CO6:** Demonstrate database connectivity with applications.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 2 and 5]** **Planning the Computer Program:** Concept of problem solving, Problem definition, Program design, Debugging, Types of errors in programming, Documentation. **Techniques of Problem Solving:** Flowcharting, decision table, algorithms, Structured programming concepts, Programming methodologies viz. top-down and bottom-up programming. **Overview of Python Programming:** History, Features, Structure of a Python Program, Elements of Python, IDEs for python, Python Interpreter, Using Python as calculator, Python shell, Indentation. **Introduction to Python:** Atoms, Identifiers and keywords, Literals, Strings, Operators (Arithmetic operator, Relational operator, Logical or Boolean operator, Assignment, Operator, Ternary operator, Bit wise operator, Increment or Decrement operator). **Creating Python Programs:** Input and Output Statements, Control statements (Looping-while Loop, for Loop, Loop Control, Conditional Statement- if...else, Difference between break, continue and pass).	20
II	**[Course Outcome(s) No.: 1, 3, 4 and 6]** **Structures**: • Numbers, • Strings (Introduction, Accessing Strings, Basic Operations, String slices, Functions), • Lists (Introduction, Accessing list, Basic Operations, Working with Lists, Functions), • Tuples (Introduction, Accessing tuples, Basic Operations, Working with tuples, Functions), • Sets (Introduction, Accessing sets, Basic Operations, Working with sets, Functions), • Dictionary (Introduction, Accessing values in dictionaries, working with dictionaries), **Functions:** Defining a function, calling a function, Types of functions, Function Arguments, Anonymous functions, Global and local variables. **Introduction to Advanced Python:** Objects and Classes, Inheritance, File Handling, Regular Expressions, Event Driven Programming, GUI Programming. Basic concepts of concepts of Package and modules.	20

Text Books:

- C. R. Severance, Python for Informatics: Exploring Information**,** CreateSpace Independent Publishing Platform, 2013.
- P. Wentworth, J. Elkner, Allen B. Downey & C. Meyers, how to Think Like a Computer Scientist: Learning with Python**,** Open Book Project, 2012.

Reference Books:

- M. Lutz, Learning Python: Powerful Object-Oriented Programming, O′Reilly, 2013.
- W. J. Chun, Core Python Applications Programming, Pearson Prentice Hall, 2012.
- A. Martelli, Python in a Nutshell, Oreilly & Associates Inc, 2006.

<table>
<tr><td>Course No: 6</td><td colspan="3">Course Name: Python Programming Lab
(Offered by CEA Department)</td><td colspan="6">Course Code: BCAE 0809</td></tr>
<tr><td rowspan="2">Batch:

2024-2028</td><td rowspan="2">Programme: B. Sc. Mathematics
(With specialization in Data Science)</td><td rowspan="2">Semester:

II</td><td>L</td><td>T</td><td>P</td><td>J</td><td>Credit</td><td>Contact Hrs. Per Week: 2</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>0</td><td>1</td><td>Total Hours: 24</td></tr>
<tr><td colspan="3">Total Evaluation Marks: 100

Internal: 50 Marks
External: 40 Marks
Attendance: 10 Marks</td><td colspan="6">Examination Duration: End Term (2 hours)

Pre-requisite of course: Nil
Nature of Course: Minor course offered by other department of same faculty</td></tr>
<tr><td>Course Objective</td><td colspan="8">The course is designed to provide basic knowledge of Python. Python programming is intended for software engineers, system analysts, program managers and user support personnel who wish to learn the Python programming language. This course focuses on employability and skill development aligned with all CO’s.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: To develop proficiency in creating based applications using the Python Programming Language.
CO2: To be able to understand the various data structures available in Python programming language andapply them in solving computational problems.
CO3: To be able to do testing and debugging of code written in Python.
CO4: To be able to do text filtering with regular expressions in Python.</td></tr>
<tr><td colspan="9">COURSE SYLLABUS</td></tr>
<tr><td>Module No.</td><td colspan="7">Content</td><td>Hours</td></tr>
<tr><td>I & II</td><td colspan="7">1. Write a Python program to solve (x + y) * (x - y).
2. Write a Python program to convert all time units into seconds.
3. Write a Python program that determines whether a given number (accepted by the user) is even or odd and prints an appropriate message to the user.
4. Write a menu driven program to convert the given temperature from Fahrenheit to Celsius and vice versa depending upon user’s choice.
5. Write a menu-driven program, using user-defined functions to find the area of rectangle, square, circle and triangle by accepting suitable input parameters from user.
6. WAP to calculate total marks, percentage and grade of a student. Marks obtained in each of the three subjects are to be input by the user. Assign grades according to the following criteria:
Grade A: Percentage >=80
Grade B: Percentage>=70 and <80
Grade C: Percentage>=60 and <70
Grade D: Percentage>=40 and <60
Grade E: Percentage<40
7. WAP to display the first n terms of Fibonacci series.
8. WAP to find factorial of the given number.
9. WAP to find sum of the following series for n terms: 1 – 2/2! + 3/3! -----n/n!.
10. WAP to calculate the sum and product of two compatible matrices.
11. Write a menu-driven program to create mathematical 3D objects
I. Curve
II. Sphere
III. Cone
IV. Arrow
V. Ring
VI. Cylinder.</td><td>24</td></tr>
</table>

Text Books:

- A. B. Downey, Think Python: How to Think Like a Computer, Shroff/O'Reilly, 2016.
- P. Wentworth, J. Elkner, Allen B. Downey, & C. Meyers, How to Think Like a Computer Scientist: Learning with Python**,** Open Book Project, 2012.

Reference Books:

- J. V. Guttag, Introduction to Computation and Programming Using Python**,** MIT Press, 2013.
- R. Nageswara Rao**,** Core Python Programming**,** Dreamtech Press, 2018.
- W. J. Chun, Core Python Programming, Pearson Education, 2007.
- M. T. Goodrich, R. Tamassia & M. H. Goldwasser**,** Data Structures and Algorithmsin Python, Wiley, 2013·

Course No: 1	**Course Name:** Project Management **(Offered by IBM)**							**Course Code:** BBAO 8004
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** II	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs. Per Week:** 3
			3	0	0	0	3	**Total Hours:** 40
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Nil **Nature of Course:** Multidisciplinary Course						

Course Objective	The course is designed to provide basic knowledge of types of projects, techniques of project management, project identification and selection. It also provides knowledge of project scheduling and networking along with EVA and project termination process. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Develop work breakdown structure of a project **CO2:** Identify the costs associated to the project management. **CO3:** Apply the techniques like CPM and PERT. **CO4:** Identify the sources of finance for the purpose of project funding.

COURSE SYLLABUS

Module No.	**Content**	**Hours**
I	**[Course Outcome(s) No.: 1, 2 and 4]** Definitions & Characteristics of Project, Types of Projects, Project Life Cycle, **Project Management Process:** Introduction, Tools & Techniques of Project Management. Project Team and Scope of Project Management, Project Organization. **Project Identification & Selection:** Identification, Generation of ideas, Approaches to Project Screening and Selection, Project Rating Index. Market & Demand Analysis **Techniques:** Survey & Trend Projection Methods. Project Risk Management. Project Costing: Fundamental components of Project Cost, Types of Costs: Direct, Indirect, Recurring, Non-Recurring, Fixed, Variable, Normal, Expedite costs. Project **Financing and Budgeting:** Sources of Finance, Social Cost Benefit Analysis (SCBA) of Project.	20
II	**[Course Outcome(s) No.: 3]** **Project Scheduling and Network Analysis:** Steps in Project Scheduling and Network design, Introduction to CPM and PERT. Monitoring and Control: Planning-Monitoring and Control Cycle. Project Management Information System. Milestone Analysis and Tracking Gantt chart. **Earned Value Analysis (EVA):** Planned Value(PV), Earned Value (EV), Cost Variance (CV), Schedule Variance (SV), Cost performance Index (CPI), Schedule performance Index (SPI). **Project Termination:** Types of Terminations, Project Termination Process.	20

Text Book:

- P. Chandra, Project- Preparation, Appraisal, Budgeting and Implementation, TMH, 1987.

Reference Books:

- J. R. Meredith & S. J. Mantel Jr., Project Management- A Managerial Approach, John Wiley & Sons, 2008.
- S. Marwah, Project Management, Dreamtech Press, 2011.
- M. R. Gopalan, Project Management Core Text Book, Wiley, 2014.
- N. D. Vohra, Quantitative Techniques in Management, McGraw Hill Education, 2017.
- M. B. Shukla, Entrepreneurship and Small Business Management, Kitab Mahal, 2007.

Course No: 2	**Course Name:** Language Skills- II **(Offered by English Department)**							**Course Code:** BELA 0004
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** II	**L** 2	**T** 0	**P** 0	**J** 0	**Credits** 2	**Contact Hrs Per Week:** 2 **Total Hours:** 30

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Nil **Nature of Course:** Ability Enhancement Course

Course Objective	The objectives of this course are to • Sharpen oral skills of the learners, • Equip the learners with some added knowledge of English Language skills, • Enable them to write English with correctness, • Make the learners contextually apply the acquired language skills, and • Enhance their reading competence. • This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Orally describe a situation in present and past, **CO2:** Read & comprehend a text with proper understanding, **CO3:** Enhance their writing skills, **CO4:** Analyze graphical data in writing, **CO5:** Apply the acquired language skills in context, and **CO6:** Enrich their vocabulary in terms of contextual and situational background.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2, 3 and 4]** **Introducing the course details and assessment structure** **Describing Situations through Pictures:** Describing Pictures orally & in written form **Reading**: Reading a text to understand the content, identify and use language aspects as given below: **Text**: "The Only American from Our Village" by Arun Joshi • **Punctuation Marks**: capitalization, full stop, comma, question mark, exclamatory mark, colon, semi-colon. • **Word Formation:** Inflection, Derivation, Compounding, Blending & Clipping • **Question Tags**: Formation and usage **Reading Comprehension:** Reading of a passage and its comprehension. **Writing Skills:** 1. Film Review 2. Development of story using key expressions **Presentation skills:** Planning and delivery	20
II	**[Course Outcome(s) No.: 1, 2, 3, 5 and 6]** **Spoken Activity:** Describing a past event **Reading**: Reading to understand the content, identify and use language aspects as given below: **Text:** "How the Camel Got his Hump" by Rudyard Kipling • **Narration**: Direct into Indirect narration and its conversion. • **Conditional Sentences**: Types and usage **Arranging ideas systematically:** Jumbled Sentences **Comprehension of Graphical Data:** Describing graphs **Vocabulary:** One word substitution **Writing Skills:** • Precis Writing • Letter to the Editor	20

Text Books:

- R. Murphy, Intermediate English Grammar. Cambridge University Press, 2018.
- G. Leech & J. Svartvik., A Communicative Grammar of English. Longman, 2003.
- M. Swan, Practical English Usage, OUP, 2016.

Reference Books:

- D. Jones, English Pronouncing Dictionary, Cambridge University Press, 2006.
- J. C. Nesfield, English Grammar: Composition and Usage, Macmillan Publishers, 2019.
- A. S. Hornby, Advanced Learners' Dictionary of Current English, OUP, 2015.

Course No: 2	**Course Name:** Human Values and Environment studies **(Offered by Chemistry & English Departments)**							**Course Code:** BCHO 0012
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** II	**L** 2	**T** 0	**P** 0	**J** 0	**Credits** 2	**Contact Hrs. Per Week:** 2 **Total Hours:** 30

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Nil **Nature of Course:** VAC

Course Objective	The mission of the course on 'Human Values and Environmental Studies' is to create morally articulate solutions to be truthful and just and to become responsible towards humanity. The course seeks to establish a continuous interest in the learners to improve their thought process with intent to develop a new generation of responsible citizens capable of addressing complex challenges faced by the society due to disruptions in human interactions effecting human values. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Building fundamental knowledge of the interplay of markets, ethics, and law **CO2:** Identify various challenges faced by individual to counter unethical issues **CO3:** Understand core concepts for business ethic and core concepts of anti-corruption **CO4:** Conceptualize a morally articulate solution evolver to management issues in general, Issues of sustainable development for a better environment. **CO5:** Apply environmental degradation techniques for sustainable development. **CO6:** Analyze the negotiations and international efforts to save environment. **CO7:** Understand the efforts made by UN in Sustainable Development.

COURSE SYLLABUS

Module No.	**Content**	**Hours**
I	**[Course Outcome(s) No.: 1, 2, 3, 4 and 5]** **Human Values**- Introduction- Values, Characteristics, Types, Developing Value system in Indian Organization Understanding Value Education Ethics, Morality & Values (Personal, Professional & Social Ethics) Fundamental Values: Humility, Integrity and Honesty Values in Business Management, value-based Organization, Trans –cultural Human values in Management. Swami Vivekananda's philosophy of Character Building, Gandhi's concept of Seven Sins, APJ Abdul Kalam view on role of parents and Teachers. **Self-Exploration and Self Development** Human Values and Present Practices – Issues: Corruption and Bribe, Privacy Policy in Web and social media, Cyber threats, Online Shopping etc. Remedies UK Bribery Act, **Introduction to sustainable policies and practices in Indian Economy. Principles of Ethics** Case Studies: 1. The Violation of Privacy 2. Giving In or Giving Up, 3. May the Truth Be with You **Secular and Spiritual Values in Management**- Introduction- Secular and Spiritual values, features, Levels of value Implementation. Features of spiritual Values, The Pursuit of Purushartha: Dharma, Artha, Kama & Moksha Documentaries:	15

	1. The Modern Times 2. Right Here Right Now 3. Story of Stuff **Corporate Social Responsibility**- Nature, Levels, Phases and Models of CSR, Corporate Governance. CSR and Modern Business Tycoons Ratan Tata, Azim Premji and Bill Gates. **Ecosystem:** Concept, structure & functions of ecosystem: producer, consumer, decomposer, food web, food chain, energy flow, Ecological pyramids Conservation of Biodiversity- In-situ & Ex-situ conservation of biodiversity Role of individual in Pollution control Human Population & Environment Sustainable Development India and UN Sustainable Development Goals Concept of circular economy and entrepreneurship.	
II	**[Course Outcome(s) No.: 1, 6 and 7]** **Holistic Approach in Decision making**- Decision making, the decision-making process, The Bhagavad Gita: Techniques in Management, Dharma and Holistic Management. Ethical Decision Making: Rationality, Critical Thinking, Problem Solving & Decision Making. **Discussion through Dilemmas** – Freedom, Individual Rights & Social Welfare Approach Dilemmas in Marketing and Pharma Organizations, moving from Public to Private – monopoly context, Dilemma of privatization, Dilemma on liberalization, Dilemma on social media and cyber security, Dilemma on Organic food, Dilemma on standardization, Dilemma on Quality standards. **Case Studies:** 1. Cyber Harassment 2. The case of Surrogacy 3. The Case of Euthanasia **Environmental Laws -** International Advancements in Environmental Conservation Role of National Green Tribunal Air Quality Index. Importance of Indian Traditional knowledge on environment, Bio assessment of Environmental Quality, Environmental Management System, Environmental Impact Assessment and Environmental Audit.	15

Text Books:

- R. R. Gaur, R. Sangal & G. P. Bagaria, A foundation Course in Human Values and Professional Ethics, Excel Books, 2010.
- M. J. Sandel, JUSTICE: What's the Right Thing to Do?, Penguin Books Ltd., 2010.
- A. N. Tripathi, Human Values, New Age International, 2019.
- N. K. Uberoi, Environmental Management, Excel Books, 2004.
- D. Kahneman, Thinking, Fast and Slow, Penguin, 2011.

References:

- https://www.un.org/sustainabledevelopment/sustainable-development-goals/
- https://www.india.gov.in/my-government/schemes
- https://www.legislation.gov.uk/ukpga/2010/23/contents

SYLLABI OF SUBJECTS

Second Year Courses

Course No: 1	**Course Name:** Algebra & Mathematical Methods							**Course Code:** BMAC 0003
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:**	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 6**
		III	5	1	0	0	6	**Total Hours: 60**

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours)
	Pre-requisite of course: Differential Calculus &Integral Calculus, Matrices, Diff. Equations
	Nature of Course: Major Course as per common minimum syllabus

Course Objective	This course will develop a profound understanding of group, subgroup and their types, homomorphism and isomorphism, ring, subring, integral domain and field. This will make the students able to prove the results based on groups, subgroups and rings. This course will also provide the knowledge of Lpalce transform and its properties, Fourier transform along with calculus of variations. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Group theory is one of the building blocks of modern algebra. Objective of this course is to introduce students to basic concepts of Group, Ring theory and their properties. **CO2:** A student learning this course gets a concept of Group, Ring, Integral Domain and their properties. This course will lead the student to basic course in advanced mathematics and Algebra. **CO3:** The course gives emphasis to enhance students' knowledge of functions of two variables, Laplace Transforms, Fourier Series. **CO4:** On successful completion of the course, students should have knowledge about higher different mathematical methods and will help him in going for higher studies and research.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2, 3 and 4]** Introduction to Indian ancient Mathematics and Mathematicians. **Algebra I**: Equivalence relations and partitions, Congruence modulo n, Definition of a group with examples and simple properties, Subgroups, Generators of a group, Cyclic groups. Permutation groups, Even and odd permutations, The alternating group, Cayley's theorem, Direct products, Coset decomposition, Lagrange's theorem and its consequences, Fermat and Euler theorems. **Mathematical Methods I**: Expansion of function of two variables, Taylor's theorem and Maclaurin's theorem for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange multiplier method, Jacobians, Functional dependence. Existence theorems for Laplace transforms, Linearity of Laplace transform and their properties, Laplace transform of the derivatives and integrals of a function, Convolution theorem, inverse Laplace transforms, Solution of the differential equations using Laplace transforms.	30
II	**[Course Outcome(s) No.: 1, 2, 3 and 4]** **Algebra II**: Normal subgroups, Quotient groups, Homomorphism and isomorphism, Fundamental theorem of homomorphism, Theorems on isomorphism. Rings, Subrings, Integral domains and fields, Characteristic of a ring, Ideal and quotient rings, Ring homomorphism, Field of quotient of an integral domain. **Mathematical Methods II**: Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Practical harmonic analysis, Fourier transforms (finite and infinite). Calculus of Variations-Variational problems with fixed boundaries, Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives, Functionals dependent on more than one independent variable, Variational problems in parametric form.	30

Text Books:

- J.B. Fraleigh, A first course in Abstract Algebra, Addison-Wesley, 2003.
- T.M. Apostol, Mathematical Analysis, Pearson, 2004.
- G.F. Simmons, Differential Equations with Application and Historical Notes, TMH, 2017.
- R. C. Chandel, H. Kishan, R. K. Shrivastava, M. Sharma & V. Singh, Algebra, RP Publications, 2022.
- Course Books published in Hindi

Reference Books:

- Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2011.
- N. Herstein, Topics in Algebra, John Wiley & Sons, 1975.
- R. C. Chandel, H. Kishan, S. Kumar, M. Sharma & RK. Shrivastava, Mathematical Methods, RPP, 2022.
- Suggested digital plateform: NPTEL/SWAYAM/MOOCS

Course No: 2	**Course Name:** Differential Equations & Mechanics							**Course Code:** BMAC 0004
Batch:	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:**	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 6**
2024-2028		IV	5	1	0	0	6	**Total Hours: 60**

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Differential Equations and Geometry **Nature of Course:** Major Course as per common minimum syllabus

Course Objective	This course will develop a profound understanding of solution of second order linear differential equations with variable coefficients and Partial differential equations of first and higher orders. This will make the students able to prove the results based on work energy principle, virtual work and catenary of uniform length. This course will also provide the knowledge of SHM, motion under resisting medium, rocket motion and Kepler's laws of motion. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** The objective of this course is to familiarize the students with various methods of solving differential equations, partial differential equations of first order and second order and to have qualitative applications. **CO2:** A student doing this course is able to solve differential equations and is able to model problems in nature using ordinary differential equations. After completing this course, a student will be able to take more courses on wave equation, heat equation, diffusion equation, gas dynamics, non-linear evolution equation etc. These entire courses are important in engineering and industrial applications for solving boundary value problem. **CO3:** The object of the paper is to give students knowledge of basic mechanics such as simple harmonic motion, motion under other laws and forces. **CO4:** The student, after completing the course can go for higher problems in mechanics such as hydrodynamics. This will be helpful in getting employment in industry.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 4]** **Second order linear differential equations with variable coefficients**: Use of a known solution to find another, normal form, method of undetermined coefficients, variation of parameters, Series solutions of differential equations, Power series method. Bessel, Legendre, Hypergeometric functions with properties, Recurrence & generating relations. **Statics:** Virtual work, Stable and Unstable equilibrium, Catenary, Catenary of uniform strength. **Kinematics:** Velocities and accelerations along radial and transverse directions and along tangential and normal directions.	30
II	**[Course Outcome(s) No.: 1, 2 and 3]** **Partial Differential Equations**: Origin of first order partial differential equations. Partial differential equations of I order and degree one, Lagrange's solution, Partial differential equation of first order and degree greater than one. Charpit's method of solution, Surfaces Orthogonal to the given system of surfaces. Origin of second order PDE, Solution of partial differential equations of the second and higher order with constant coefficients, Classification of linear partial differential equations of second order, Solution of second order partial differential equations with variable coefficients, Monge's method of solution. **Kinetics**: Simple Harmonic motion, Motion under other law of forces. Elastic strings, Motion in resisting medium, Constrained motion, Motion on smooth and rough plane curves. Motion of particles of varying mass, Rocket motion, Central orbit, Kepler's laws of motion, Motion of particle in three dimensions, Rotating frame of reference, Rotating Earth, Acceleration in terms of different coordinates systems.	30

Text Books:

- B. Rai, D.P. Choudhary & H. J. Freedman, A Course of Ordinary Differential Equations, Narosa, 2002.
- G.F. Simmons, Differential Equations with Application and Historical Notes, TMH, 2017.
- R.C. Hibbeler, Engineering Mechanics-Statics, Pearson, 2015.
- R.C. Hibbeler, Engineering Mechanics-Dynamics, Prentice-Hall, 2004.
- R. C. Chandel, H. Kishan, S. S. Yadav, M. Sharma & V. Singh, Differential Equations, RP Pub., 2022
- L.E. Elsgolts, Differential Equation and Calculus of variations, University Press of the Pacific, 2003.
- Course Books published in Hindi.

Reference Books:

- Ian N. Sneddon, Elements of Partial Differential Equations, Dover Publication, 2006.
- A. Nelson, Engineering Mechanics, Statics and Dynamics, Tata McGraw Hill, 2017.
- R. C. Chandel, H. Kishan, A. K. Sharma, K. M. Agrawal & S. Verma, Mechanics, RP Pub., 2022
- J.L. Synge & B.A. Griffith, Principles of Mechanics, TMH, 1959.
- Suggested digital plateform: NPTEL/SWAYAM/MOOCs

Course No: 3	**Course Name:** Statistics for Data Science-II						**Course Code:** BMAC 0102
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** III	**L** 3	**T** 1	**P** 0	**J** 0	**Credits** 4	**Contact Hrs Per Week:** 4 **Total Hours:** 40
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Statistics for Data Science - I **Nature of Course:** Major- 2 Course					

Course Objective	This course will develop a profound understanding of discrete and continuous probability distributions, Statistical inference and non-parametric statistics. This will also make the students able to know about central limit theorem, types of sampling, statistical hypotheses and analysis of variance (ANOVA). Further, a deep understanding of errors in sampling, level of significance, t distribution, chi-square distribution and F distribution will be developed in this course. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to: **CO1:** Apply the discrete and continuous probability distributions. **CO2:** Understand the central limit theorem, law of large numbers and Statistical inference analysis. **CO3:** Identify sampling errors and make statistical hypotheses to apply different distributions. **CO4:** Learn the concept of analysis of variance and use different tests in non-parametric statistics.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** **Discrete Probability Distributions**: Binomial, Poisson, Negative Binomial, and Geometric distributions. **Continuous Probability Distributions**: Uniform, Normal, Gamma, and Exponential distributions. Central limit theorem and law of large numbers. **Statistical Inference**: Unbiasedness, maximum likelihood estimation, interval estimation.	20
II	**[Course Outcome(s) No.: 3 and 4]** Sampling and non-sampling errors, types of sampling, statistical hypotheses, level of significance, p-value, the t distribution, chi-square distribution, and F-distribution. **Non-parametric statistics**: Wald Wolfowitz run test, median test, sign test, Mann-Whitney-Wilcoxon- U- test. ANOVA-one way and two way.	20

Text Books:

- R. V. Hogg, J. Mckean & A. T. Craig, Introduction to Mathematical Statistics, Pearson, 2004.
- V. K. Rohatgi & A. K. Md. E Saleh, An Introduction to Probability and Statistics, Wiley, NY, 2005.

Reference Books:

- V. K. Rohatgi, An introduction to probability theory and mathematical statistics, Wiley Eastern, 1986.
- S. C. Gupta & V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2014.

SYLLABI OF SUBJECTS

Third Year Courses

Course No: 1	**Course Name:** Group and Ring Theory & Linear Algebra							**Course Code:** BMAC 0005
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** V	**L** 4	**T** 1	**P** 0	**J** 0	**Credits** 5	**Contact Hrs Per Week: 5** **Total Hours: 50**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Algebra, Matrices **Nature of Course:** Major Course as per common minimum syllabus						

Course Objective	This course will develop a profound understanding of group theory, ring theory, vector space, subspace, linear transformations and rank-nullity theorem. This will make the students able to prove the results based on principal ideal domain and Euclidian domain. This course will also provide the knowledge of inner product space and Gram-Schmidt orthogonalization process. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Liner algebra is a basic course in almost all branches of science. The objective of this course is to introduce a student to the basics of linear algebra and some of its applications. **CO2:** Students will be able to know the concepts of group, ring and other related properties, which will prepare the students to take up further applications in the relevant fields. **CO3:** The student will use this knowledge in computer science, financial mathematics, industrial mathematics and biomathematics. **CO4:** After completion of this course, students will appreciate its interdisciplinary nature.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2, 3 and 4]** Introduction to Indian ancient Mathematics and Mathematicians **Group Theory**: Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups. Conjugacy classes, The class equation, p-groups, The Sylow theorems and consequences, Applications of Sylow theorems; Finite simple groups, Nonsimplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications. **Linear Algebra I**: Vector spaces, Subspaces, Linear independence and dependence of vectors, Basis and Dimension, Quotient space. Linear transformations, The Algebra of linear transformations, rank nullity theorem, their representation as matrices.	25
II	**[Course Outcome(s) No.: 1, 2, 3 and 4]** **Ring theory**: Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion, Unique factorization in Z [x]. Divisibility in integral domains, Irreducibles, Primes, Unique factorization domains, Euclidean domains. **Linear Algebra II**: Linear functionals, Dual space, Characteristic values, Cayley Hamilton Theorem. Inner product spaces and norms, Cauchy-Schwarz inequality, Orthogonal vectors, Orthonormal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process, Bilinear and Quadratic forms.	25

Text Books:

- N. Herstein, Topics in Algebra, Wiley, 2006.
- K. Hoffman and R. Kunze, Linear Algebra, Pearson, 2018.

Reference Books:

- Course Books published in Hindi
- Suggested digital plateform: NPTEL/SWAYAM/MOOCs

Course No: 2	**Course Name:** Number Theory & Game Theory							**Course Code:** BMAE 0001
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** V	**L** 4	**T** 1	**P** 0	**J** 0	**Credits** 5	**Contact Hrs Per Week: 5** **Total Hours: 50**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Algebra, Linear Programming Problem **Nature of Course:** Elective Course						

Course Objective	This course will develop a profound understanding of theory of numbers and game theory. This course will provide the knowledge of Congruences, Diophantine Equations, pay off matrix, and generating functions. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Upon successful completion, students will have the knowledge and skills to solve problems in elementary number theory and also apply elementary number theory to cryptography. **CO2:** This course provides an introduction to Game Theory. Game Theory is a mathematical framework which makes possible the analysis of the decision making process of interdependent subjects. It is aimed at explaining and predicting how individuals behave in a specific strategic situation, and therefore help improve decision making. **CO3:** A situation is strategic if the outcome of a decision problem depends on the choices of more than one person. Most decision problems in real life are strategic. **CO4:** To illustrate the concepts, real-world examples, case studies, and classroom experiments might be used.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 3]** **Theory of Numbers:** Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler's phi-function. **Congruences:** Congruence modulo powers of prime; primitive roots and their existence; quadratic residues; Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol. **Game Theory I:** Introduction, overview, uses of game theory, some applications and examples, and formal definitions of: the normal form, payoffs, strategies, pure strategy Nash equilibrium. Introduction, characteristic of game theory, Two- person zero-sum game, Pure and Mixed strategies, Saddle point and its existence.	25
II	**[Course Outcome(s) No.: 1, 2 and 4]** **Diophantine Equations:** Solutions of ax+by=c,$x^n + y^n = z^n$;properties of Pythagorean triples; sums of 2, 4, 5 squares; assorted examples of diophantine equations. **Generating Functions and Recurrence Relations:** Generating Function Models, Calculating coefficient of generating functions, Partitions, Exponential Generating Functions, A Summation Method. Recurrence Relations: Recurrence Relation Models, Divide and conquer Relations, Solution of Linear Recurrence Relations, Solution of Inhomogeneous Recurrence Relations, Solutions with Generating Functions. **Game Theory II:** Fundamental Theorem of Rectangular games, Concept of Dominance, Dominance and Graphical method of solving Rectangular games. Relationship between rectangular game and Linear Programming Problem, Solving rectangular game by Simplex method, reduction of m x n game and solution of 2x2, 2 x s, and r x 2 cases by graphical method, algebraic and linear programming solution of m x n games.	25

Text Books:

- D. M. Burton, Elementary Number Theory, Universal Book Stall, New Delhi, 2002.
- I. Niven, H. S. Zuckerman and H. L. Montegomery, An Int. to the Theory of Numbers (6^{th} edition) John Wiley and sons, Inc., New York, 2003.
- Prajit Dutta, Strategies and Games, MIT Press, http://www.ece.stevens-ch.edu/~ccomanic/ee800c.html
- V. K. Balakrishnan, Introductory Discrete Mathematics, Dover Publications, 1996.

Reference Books:

- Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003
- V. K. Balakrishnan, Schaum's Outline of Theory and Problems of Combinatorics Including Concepts of Graph Theory, Schaum's Outline, 1994.
- Allan MacKenzie, Game Theory for Wireless Engineers, Synthesis lectures on Communications, 2006.
- Suggested digital plateform: NPTEL/SWAYAM/MOOCS
- Course Books published in Hindi.

Course No: 3	**Course Name:** Graph Theory & Discrete Mathematics						**Course Code:** BMAE 0002
Batch:	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:**	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 5**
2024-2028		V	4	1	0	0	5	**Total Hours: 50**

Total Evaluation Marks: 100	**Examination Duration:**
Mid Term: 30 Marks	Mid Term (2 hours), End Term (3 hours)
End Term: 50 Marks	**Pre-requisite of course:** Algebra
Internal Assessment: 20 Marks	**Nature of Course:** Elective Course

Course Objective	This course will develop a profound understanding of graph theory, propositional logic and boolean algebra. This course will provide the knowledge of combinatorics and theory of automata. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** Upon successful completion, the students will have the knowledge of various types of graphs, their terminology and applications. **CO2:** After Successful completion of this course, students will be able to understand the isomorphism and homomorphism of graphs. This course covers the basic concepts of graphs used in computer science and other disciplines. The topics include path, circuits, adjacency matrix, tree, coloring. After successful completion of this course, the student will have the knowledge graph coloring, color problem, vertex coloring. **CO3:** After successful completion, students will have the knowledge of Logic gates, Karnaugh maps and skills to proof by using truth tables. Students will also be able to apply the basics of the automation theory, transition function and table. **CO4:** This course covers the basic concepts of discrete mathematics used in computer science and other disciplines that involve formal reasoning. The topics include logic, counting, relations, hasse diagram and Boolean algebra. After successful completion of this course, the student will have the knowledge in Mathematical reasoning, combinatorial analysis, discrete structures and Applications.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2, 3 and 4]** **Graph Theory I:** Introduction to graphs, basic properties of graphs, Simple graph, multi graph, graph terminology, representation of graphs, Bipartite, regular, planar and connected graphs, connected components in a graph, Euler graphs, Directed, Undirected, multi-graph, mixed graph. Walk and unilateral components, unicursal graph, Hamiltonian path and circuits, Graph colouring, chromatic number, isomorphism and homomorphism of graphs, Incidence relation and degree of the graph. **Propositional Logic:** Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification, proof by implication, converse, inverse contrapositive, contradiction, direct proof using truth table. **Boolean Algebra:** Basic definitions, Sum of products and products of sums, Logic gates and Karnaugh maps.	25
II	**[Course Outcome(s) No.: 1, 2, 3 and 4]** **Graph Theory II:** Operation of graph circuit, Path and circuits, Eulerian circuits, Hamiltonian path and cycles, Adjacency matrix, Weighted graph, Travelling salesman problem, Shortest path, Dijkstra's algorithm. Tree, Binary and Spanning trees, Coloring, Color problems, Vertex coloring and important properties. **Combinatories:** Inclusion- exclusion, recurrence relations (n^{th} order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relations using G.F. solution of combinatorial problem using G.F.) **Finite Automata:** Basic concepts of automation theory, Deterninistic Finite Automation (DFA), transition function, transition table, Non Deterministic Finite Automata (NDFA), Mealy and Moore machine, Minimization of finite automation.	25

Text Books:

- N. Deo, Graph Theory with Applications to Engineering and Computer Science, PHI, 2016.
- C. L. Liu, Elements of Discrete Mathematics, McGraw-Hill, 1985.
- J. P. Trembley & R. Manohar, Discrete Mathematics Structures with Applications to Computer Science, TMH, 2008.
- S. S. Ray, Graph Theory with Algorithms and Its Applications: In Applied Science and Technology, Springer, 2013.

Reference Books:

- D. B. West, Introduction to Graph Theory, Pearson, 2000.
- K. H. Rosen Discrete Mathematics and Its Applications, McGraw-Hill, 2017.
- Suggested digital plateform: NPTEL/SWAYAM/MOOCs.
- Course Books published in Hindi.

Course No: 4	**Course Name:** Differential Geometry & Tensor Analysis							**Course Code:** BMAE 0003
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** V	**L** 4	**T** 1	**P** 0	**J** 0	**Credits** 5	**Contact Hrs Per Week: 5** **Total Hours: 50**
Total Evaluation Marks: 100		**Examination Duration:** Mid Term (2 hours), End Term (3 hours)						
Mid Term: 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Pre-requisite of course:** Coordinate Geometry, Vector Calculus **Nature of Course:** Elective Course						

Course Objective	This course will develop a profound understanding of local theory of curves and surfaces, Geodesics, Gaussian and normal curvature. This course will also provide the knowledge of Tensor algebra and analysis. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** After Successful completion of this course, students should be able to determine and calculate curvature of curves in different coordinate systems. **CO2:** This course covers the Local theory of Curves, Local theory of surfaces, Geodesics, Geodesics curvature, Geodesic polars, Curvature of curves on surfaces, Gaussian curvature, Normal curvature etc. **CO3:** After Successful completion of this course, students should have the knowledge of tensor algebra, different types of tensors, Riemannian space, Ricci tensor, Einstein space and Einstein tensor etc.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 3]** **Local theory of curves:** Space curves, Examples, Plane Curves, tangent and normal and binormal, Osculating Plane, normal plane and rectifying plane, osculating circle, osculating sphere, Helices, Serret-Frenet apparatus, contact between curve and surfaces, tangent surfaces, involutes and evolutes of curves, Bertrand curves, Intrinsic equations, fundamental existence theorem for space curves. **Local Theory of Surfaces:** Parametric patches on surface curve of a surface, family of surfaces (one parameter), edge of regression, rues surfaces, skew ruled surfaces and developable surfaces, surfaces of revolution, Helicoids. **Tensor Algebra:** Vector spaces, the dual spaces, tensor product of vector spaces, transformation formulae, contraction, special tensors, symmetric tensor, inner product, associated tensor with examples. **Tensor Analysis I:** Contravariant and covariant vectors and tensors, Mixed tensors, Symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Quotient theorem, Reciprocal tensors, Christoffel's symbols, Law of transformation of Christoffel's symbols, Covariant differentiation, non- commutativity of Covariant derivative.	25
II	**[Course Outcome(s) No.: 2 and 3]** **Metric:** first fundamental form and arc length, Direction coefficients, families of curves, intrinsic properties, geodesics, canonical geodesic equations, normal properties of geodesics, geodesics curvature, Geodesic polars. Gauss-Bonnet theorem, curvature of curves on surfaces, Gaussian curvature, normal curvature, Meusneir's theorem, mean curvature, Gaussian curvature, umbilic points, lines of curvature, Rodrigue's formula, Euler's theorem. **Tensor Analysis II:** Gradient of scalars, Divergence of a contravariant vector, covariant vector and conservative vectors, Laplacian of an invariant, curl of a covariant vector, irrotational vector, with examples. Riemannian space, Riemannian curvatures and their properties, geodesics, geodesic curvature, geometrical interpretation of curvature tensor, Ricci tensor, scalar curvature, Einstein space and Einstein tensor.	25

Text Books:

- T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
- B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
- Z. Ahsan, Tensors- Mathematics of Differential Geometry, PHI, 2015.
- B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003.
- D. C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill, 1988.
- R. S. Mishra, A Course in Tensors with Applications to Reimannian Geometry, Pothishala Pvt. Ltd, Allahabad.

Reference Books:

- C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
- D. J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
- S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
- L. P. Eisenhart, An Introduction to Differential Geometry (with the use of tensor Calculus), Princeton University Press, 1940.
- I. S. Sokolnikoff, Tensor Analysis, Theory and Applications to Geometry and Mechanics of Continua, 2nd Edition, John Wiley and Sons, 1964.
- Suggested digital plateform: NPTEL/SWAYAM/MOOCs
- Course Books published in Hindi.

Course No: 5	**Course Name:** Multivariate Statistics							**Course Code:** BMAC 0103
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** V	**L** 3	**T** 1	**P** 0	**J** 0	**Credits** 4	**Contact Hrs Per Week: 4** **Total Hours: 40**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Statistics for Data Science **Nature of Course:** Major - 2 Course						

Course Objective	This course will develop a profound understanding of univariate and bivariate random variables, Multivariate normal distribution, maximum likelihood estimation (MLE), Wishart distribution and types of correlation. This course will also provide the knowledge of Principal Component Analysis and cluster analysis. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to **CO1:** Know types of random variable and correlation matrices. **CO2:** Apply multivariate normal distribution and Wishart distribution. **CO3:** Understand multiple, Partial and Canonical correlations. **CO4:** Perform principal component analysis and cluster analysis.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** Univariate and bivariate random variables, mean vectors and covariance matrices for random vectors and correlation matrices. Multivariate normal distribution, mean vector and covariance matrix, properties of multivariate normal vectors, moment generating function, maximum likelihood estimation (MLE) of mean vector and covariance matrix, Wishart distribution and its properties.	20
II	**[Course Outcome(s) No.: 3 and 4]** Simple, Multiple, Partial and Canonical correlations alongwith their properties. Principal Component Analysis: Deriving principal components (PCs), properties of PCs, PCs as projections and rotation of axes, methods for discarding components and interpretation of PCs. Cluster Analysis: Similarity and distance measures, hierarchical clustering, K-means clustering and their interpretation.	20

Text Books:

- T. W. Anderson, An Introduction to Multivariate Statistical Analysis, Wiley, 2003.
- R. A. Johnson & D.W. Wichern, Applied Multivariate Analysis, Wiley, 2002.

Reference books:

- M. S. Srivastava & C. G. Khatri, Introduction to multivariate statistics, North-Holland, 1979.
- A. C. Rencher, Multivariate Statistical Inference and its Applications, Wiley and Sons, 1998.

Course No: 6	**Course Name:** Metric Spaces & Complex Analysis							**Course Code:** BMAC 0006
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VI	**L** 3	**T** 1	**P** 0	**J** 0	**Credits** 4	**Contact Hrs Per Week: 4** **Total Hours: 40**
Total Evaluation Marks: 100		**Examination Duration:** Mid Term (2 hours), End Term (3 hours)						
Mid Term: 30 Marks		**Pre-requisite of course:** Algebra, Trignonometry and Calculus						
End Term: 50 Marks		**Nature of Course:** Major Course as per common minimum syllabus						
Internal Assessment: 20 Marks								

Course Objective	This course will develop an understanding of metric spaces, topology of metric spaces, uniform continuity, connectedness and compactness. This course will provide the knowledge of functions of a complex variable, their continuity and differentiability and theorems of complex analysis. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** The course is aimed at exposing the students to foundations of analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics. **CO2:** After completion of this course, the student will have rigorous and deeper understanding of fundamental concepts in Mathematics. This will be helpful to the student in understanding pure mathematics and in research. **CO3:** Students will be able to know the concepts of metric space, basic concepts and developments of complex analysis which will prepare the students to take up further applications in the relevant fields.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 3]** **Metric Spaces I:** Definition and examples, Sequences in metric spaces, Cauchy sequences, Complete metric space. Topology of Metric Spaces: Open and closed ball, Neighborhood, Open set, Interior of a set, limit point of a set, derived set, closed set, closure of a set, diameter of a set, Cantor's theorem, Subspaces, Dense set. **Complex Analysis I:** Analytic Functions and Cauchy-Riemann Equations: Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples. Elementary Functions and Integrals: Exponential function, Logarithmic function, Branches and derivatives of logarithms, Trigonometric function, Derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals.	20
II	**[Course Outcome(s) No.: 1, 2 and 3]** **Metric Spaces II:** Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mapping, Banach fixed point theorem. Connectedness, Connected subsets of, Connectedness and continuous mappings, Compactness, Compactness and boundedness, Continuous functions on compact spaces. **Complex Analysis II:** Antiderivatives, Proof of antiderivative theorem, Cauchy-Goursat theorem, Cauchy integral formula; An extension of Cauchy integral formula, Consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples; Laurent series and its examples, Absolute and uniformconvergence of power series, Uniqueness of series representations of power series, Isolated singular points, Residues, Cauchy's residue theorem, Residue at infinity; Types of isolated singular points, Residues at poles and its examples.	20

Text Books:

- J. W. Brown & R. V. Churchill, Complex variable and applications, McGraw Hill, 2013.
- S. Narain & P. K. Mittal, Mathematical Analysis, S. Chand, 2005.
- S. Shirali, & H. L. Vasudeva, Metric Spaces, Springer, First Indian Print, 2009.
- S. Narain & P. K. Mittal, Function of Complex Variable, S. Chand, 2005.

Reference Books:

- G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2017.
- S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, 2014.
- Suggested digital plateform: NPTEL/SWAYAM/MOOCS.
- Course Books published in Hindi.

Course No: 7	**Course Name:** Numerical Analysis & Operations Research						**Course Code:** BMAC 0007
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VI	**L** 3	**T** 1	**P** 0	**J** 0	**Credits** 4	**Contact Hrs Per Week: 4** **Total Hours: 40**

Total Evaluation Marks: 100	**Examination Duration:** Mid Term (2 hours), End Term (3 hours)
Mid Term: 30 Marks	**Pre-requisite of course:** Calculus, Differential Equations and LPP
End Term: 50 Marks	**Nature of Course:** Major Course as per common minimum syllabus
Internal Assessment: 20 Marks	

Course Objective	This course will develop a profound understanding of numerical solution of algebraic and transcendental equations, ordinary differential equations, numerical integration and differentiation, Eigen value problem & solution of simultaneous linear equations. This course will also provide the knowledge of methods for solving LPP, transportation and assignment problems. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	**CO1:** The aim of this course is to teach the student the application of various numerical technique for variety of problems occurring in daily life. At the end of the course, the student will be able to understand the basic concept of Numerical Analysis and to solve algebraic and differential equation. **CO2:** The main outcome will be that students will be able to handle problems and finding approximated solution. Later he can opt for advance course in Numerical Analysis in higher Mathematics. **CO3:** The student will be able to solve various problems based on convex sets and linear programming. The successful completion of this paper will enable the students to apply the basic concepts of transportation problems and its related problems to apply in further concepts and application of operations research.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 3]** **Numerical Analysis I:** Solution of equations: bisection, Secant, Regular Falsi, Newton Raphson's method, Newton's method for multiple roots, Interpolation, Lagrange and Hermite interpolation, Difference schemes, divided differences, Interpolation formula using differences. Numerical differentiation. Numerical Quadrature: Newton Cotes Formulas, Gaussian Quadrature Formulas. System of Linear equations: Direct method for solving systems of linear equations (Gauss elimination, LU Decomposition, Cholesky Decomposition), Iterative methods (Jacobi, Gauss Seidel, Relaxation methods). The Algebraic Eigen value problem: Jacobi's method, Given's method, Power method. **Operations Research I:** Introduction, Convex sets, fundamental theorem of linear programming, basic solution, Simplex method, introduction to artificial variables, two phase method, Big-M method and their comparison.	20
II	**[Course Outcome(s) No.: 1, 2 and 3]** **Numerical Analysis II:** Numerical solution of Ordinary differential equations: Euler method, single step methods, Runge-Kutta method, Multi-step methods, Milne-Simpson method, Types of approximation: Least Square polynomial approximation, Uniform approximation, Chebyshev polynomial approximation. Difference Equations and their solutions, Shooting method and Difference equation method for solving Linear second order differential equation with boundary conditions of first, second and third type. **Operations Research II:** Resolution of degeneracy, duality in linear programming problems, primal dual relationships, revised simplex method, sensitivity analysis. Transportation problems, assignment problems.	20

Text Books:

- H. A. Taha, Opearations Research- An Introduction, Pearson Education, 2019.
- S. S. Sastry, Introductory methods of Numerical Analysis, PHI, 2012.
- P. K. Gupta & D. S. Hira, Problems in Operations Research: Principles and Solutions, S Chand, 2010.
- M. Goyal, Computer Based Numerical and Statistical Techniques, Laxmi Pub., Delhi, 2017.
- S. Kalavathy, Operations Research, Vikash Publication House, 2012.

Reference Books:

- M. K. Jain, S. R. K. Iyengar & R. K. Jain Numerical Methods for Engineering and scientific computation, New Age, 2012.
- W. L., Winston, Operations Research: Applications and Algorithms, Cengage Learning, 4th Ed., 2003.
- F. S. Hillier, G. J. Lieberman, B. Nag & P. Basu, Introduction to Operations Research, McGraw Hill, 2017.
- K. Swarup, P. K. Gupta & M. Mohan, Operations research, Sultan Chand & Sons, 2014.
- Suggested digital plateform: NPTEL/SWAYAM/MOOCs.
- Course Books published in Hindi.

Course No: 8	**Course Name:** Practical							**Course Code:** BMAC 0802
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VI	**L** 0	**T** 0	**P** 4	**J** 0	**Credits** 2	**Contact Hrs Per Week: 2** **Total Hours: 24**
Total Evaluation Marks: 100 **Internal:** 50 Marks **External:** 40 Marks **Attendance**: 10 Marks		**Examination Duration:** End Term (2 hours) **Pre-requisite of course:** Nil **Nature of Course:** Major Course as per common minimum syllabus						

Course Objective	This lab aims to develop an understanding of numerical solution of equations, system of equations, numerical integration, Interpolation and solution of Eigen value problems with computer programs using programming languages and software tools. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	The main objective of the course is to equip the student to solve the transcendental and algebraic equations, system of linear equations, ordinary differential equations, Interpolation, Numerical Integration, Method of finding Eigenvalue by Power method (up to 4 × 4), Fitting a Polynomial Function (up to third degree).

COURSE SYLLABUS

Module No.	Content	Hours
I	List of the practicals to be done using computer algebra software (CAS), for example Mathematica/MATLAB/Maple/ Maxima/Scilab etc, 1. Solution of transcendental and algebraic equations by i) Bisection method ii) Newton Raphson method (Simple root, multiple roots, complex roots). iii) Secant method. iv) Regula Falsi method. 2. Solution of system of linear equations i) LU decomposition method ii) Gaussian elimination method iii) Gauss-Jacobi method iv) Gauss-Seidel method 3. Interpolation i) Lagrange Interpolation ii) Newton's forward, backward and divided difference interpolations 4. Numerical Integration i) Trapezoidal Rule ii) Simpson's one third rule iii) Weddle's Rule iv) Gauss Quadrature 5. Method of finding Eigenvalue by Power method (up to 4 × 4) 6. Fitting a Polynomial Function (up to third degree) 7. Solution of ordinary differential equations i) Euler method ii) Modified Euler method iii) Runge Kutta method (order 4) (iv) The method of successive approximations (Picard)	24

Text Books:

- M. K. Jain, S. R. K. Iyengar & R. K. Jain Numerical Methods for Engineering and scientific computation, NEW AGE, 2012.
- M. Goyal, Computer Based Numerical and Statistical Techniques, Laxmi Publications, Delhi, 2017.

Course No: 9	**Course Name:** Time Series and Stochastic Processes							**Course Code:** BMAC 0104
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VI	**L** 3	**T** 1	**P** 0	**J** 0	**Credits** 4	**Contact Hrs Per Week: 4** **Total Hours: 40**
Total Evaluation Marks: 100		**Examination Duration:** Mid Term (2 hours), End Term (3 hours)						
Mid Term: 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Pre-requisite of course:** Multivariate Statistics **Nature of Course:** Major – 2 Course						

Course Objective	This course will develop a profound understanding of time series and its components, growth curves, autocovariance and autocorrelation function, Autoregressive process and moving average process of general order. This course will also provide the knowledge of ARIMA models, Markov chains, and ergodicity. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to **CO1:** Use methods of determination of trend and analyse seasonal components & indices. **CO2:** Find autocovariance and autocorrelation function and use mixed ARMA process. **CO3:** Identify ARIMA models and apply Dickey Fuller test. **CO4:** Know about Markov chains, Chapman-Kolmogorov equations and ergodicity.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** Time Series, Components of time series, additive and multiplicative models, methods of determination of trend, growth curves, analysis of seasonal component and seasonal indices. Time series as stochastic process, auto covariance function (acvf), autocorrelation function (acf), partial autocorrelation function (pacf), correlogram, Autoregressive (AR) process of general order, moving average (MA) process of general order, mixed ARMA process.	20
II	**[Course Outcome(s) No.: 3 and 4]** Stationarity and invertibility conditions, Autoregressive integrated moving average (ARIMA) models, model identification, AIC, BIC. Unit root test- Dickey Fuller. Discrete and Continuous-time Markov Chains (MCs): Transition probability matrix, classification of states, Chapman-Kolmogorov equations; n-step transition and limiting probabilities, ergodicity, stationary distribution.	20

Text Books:

- A. M. Goon, M. K. Gupta & B. Dasgupta, Fundamentals of statistics, (vol. II), World Press, Calcutta, 1991.
- G. E. Box, G. M. Jenkins, G. C. Reinsel, & G. M. Ljung, Time series analysis: forecasting and control, John Wiley & Sons, 2015.
- S. Karlin & H. M. Taylor, A First Course in Stochastic Processes, Academic Press, 1995.
- J. Medhi, Stochastic Processes, New Age International, 2012.

Reference books:

- P. G. Hoel, S. C. Port & C. J. Stone, Introduction to Stochastic Processes, Waveland Pr Inc, 1986.
- S. M. Ross, Stochastic Processes, Wiley, 1996.
- P. J. Brockwell & R. A. Davis, Time Series: Theory and Methods, Springer, 2009.

Course No: 10	**Course Name:** Statistical Computation and Simulation						**Course Code:** BMAK 0101
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VI	**L** 3	**T** 0	**P** 0	**J** 0	**Credits** 3	**Contact Hrs Per Week: 3** **Total Hours: 30**

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Basic knowledge of Statistics **Nature of Course:** SEC

Course Objective	This course will develop a profound understanding of Generating probability distributions in R, central limit theorem and random number generation. This course will also provide the knowledge of Gaussian integration, Monte Carlo integration, Bootstrapping and jackknife resampling. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to **CO1:** Generate probability distributions in R and random number by various methods. **CO2:** Apply central limit theorem. **CO3:** Compute integrals using quadrature formula, Gaussian integration and Monte Carlo methods. **CO4:** Know Bootstrapping for estimation of sampling distribution.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** Generating discrete and continuous probability distributions in R, sampling from distributions. Central limit theorem, Concept of Markov chains. Simulating multivariate distributions. Random number generation: General transformation methods, Acceptance-Rejection method.	15
II	**[Course Outcome(s) No.: 3 and 4]** Methods to compute integrals: quadrature formula, double integration, Gaussian integration. Monte Carlo Methods: Monte Carlo integration, Metropolis- Hastings and Gibbs sampler and related methods. Bootstrapping, jackknife resampling. Bootstrapping for estimation of sampling distribution.	15

Text Books:

- G. Casella & C. P. Roberts, Monte Carlo Statistical methods, Springer, 2004.
- R. Christensen, W. Johnson, A. Branscum & G. S. Fishman, Monte Carlo: Concepts, Algorithms, and Applications, Springer, 1996.
- A. C. Davison, & D. V. Hinkley, Bootstrap methods and their application (No. 1). Cambridge University Press, 1997.
- M. L. Rizzo, Statistical computing with R, CRC Press, 2019.

Reference books:

- W. J. Kennedy & J. E. Gentle, Statistical computing, Marcel Dekker Ltd, 1980.
- B. D. Ripley, Stochastic simulation, John Wiley & Sons, 2009.

SYLLABI OF SUBJECTS

Fourth Year Courses

Course No: 1	**Course Name:** Real Analysis							**Course Code:** BMAC 0008	
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VII	**L** 4	**T** 1	**P** 0	**J** 0	**Credits** 5	**Contact Hrs Per Week: 5**	**Total Hours: 50**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Metric Space **Nature of Course:** Major – 1 Course							

Course Objective	This course will develop a profound understanding of countable and uncountable sets, sequences and series of real numbers. This will also make the students able to prove the results of uniform continuity and differentiability and test the uniform convergence of sequences of functions. Further, a deep understanding of measurable functions, Riemann integration and Lebesgue integration will be developed in this course. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to: **CO1:** Learn the concept of countability of real numbers and convergence of sequences. **CO2:** Understand uniform continuity and differentiability, and functions of several variables. **CO3**: Recognize difference between pointwise and uniform convergence of sequence of functions. **CO4:** Apply tests for uniform convergence. **CO5:** Learn functions of bounded variation and measurable functions. **CO6:** Determine the Riemann and Lebesgue integrability of a function.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** Countable and uncountable sets, Convergence of sequences of real numbers. **Functions of real variable**: Uniform continuity and differentiability. **Functions of several variables:** Limit, Continuity, Differentiability, Partial differentiation, Directional derivatives, Taylor's series, Inverse function theorem, Implicit function theorem, Jacobians, Fubini's theorem.	25
II	**[Course Outcome(s) No.: 3, 4, 5 and 6]** Sequence and series of functions, Pointwise and uniform convergence, Cauchy's criterion for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's test for uniform convergence, Riemann integration, Functions of bounded variation, Riemann Stieltjes integration, Lebesgue measure, Lebesgue integral, Measurable sets, Measurable functions.	25

Text Books:

- W. Rudin, Principles of Mathematical Analysis, McGraw-Hill, 2017.
- T. M. Apostol, Mathematical Analysis, Narosa Publishing House, 2002.
- S. C. Malik & S. Arora, Mathematical Analysis, New Age International Ltd., 2017.
- R. Bartle, The Elements of Integration and Lebesgue Measure, Wiley Classics Library, 1995.
- D. Somasundaram & B. Chaudhary, A First Course in Mathematical Analysis, Narosa Publishing House, 1996.

Reference Books:

- K. Ross, Elementary Analysis, The Theory of Calculus, Springer, 2013.
- H. L. Royden, Real Analysis, Macmillan Publishing Company, 2015.
- P. K. Jain & V. P. Gupta, Lebesgue Measure and Integration, New Age International Ltd., 2020.

Course No: 2	**Course Name:** Ordinary Differential Equations						**Course Code:** BMAC 0009
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VII	**L** 4	**T** 1	**P** 0	**J** 0	**Credits** 5	**Contact Hrs Per Week: 5** **Total Hours: 50**

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Differential Equations **Nature of Course:** Major – 1 Course

Course Objective	This course will develop a profound understanding for finding the solution of nth order differential equations. This course will also make the students able to find the solution of boundary value problems and analyze the stability of dynamical systems. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to: **CO1:** Understand initial and boundary value problems and find the solution of n^{th} order homogeneous and non-homogeneous differential equations. **CO2:** Determine the Eigen values and Eigen functions and learn their applications. **CO3:** Construct Green's function for the solution of boundary value problems. **CO4:** Find the stability of linear and non-linear dynamical systems.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** Introduction, Initial and Boundary value problems, Existence and Uniqueness of solutions of ordinary differential equation of first order, Lipschitz condition, Picard's method, Existence and Uniqueness theorem for ordinary differential equation of higher order, Strum-Liouville boundary value problem, Orthogonal sets of function, Eigen values and Eigen functions, Eigen function expansions, Separation and Comparison theorems.	25
II	**[Course Outcome(s) No.: 3 and 4]** Green's functions, Construction of Green's function and its application to solve the boundary value problems, Stability of autonomous system of differential equations, Critical point of an autonomous system and their classification as stable, asymptotically stable and strictly stable. Stability of linear system with constant coefficient, Linear plane autonomous system, Perturbed system, Method of Lyapunov for non-linear systems.	25

Text Books:

- M. D. Raisinghania, Ordinary Differential Equations, S. Chand & Co., 2019.
- J. N. Sharma & R. K. Gupta, Differential Equations, Krishna Prakashan Media (P) Ltd., 2015.
- E. A. Coddington & N. Levinson, Theory of Ordinary Differential Equations, McGraw Hill, 2017.

Reference Books:

- G. Birkhoff & G. C. Rota, Ordinary Differential Equations, John Wiley and Sons Inc., 1989.
- S. L. Ross, Differential Equations, John Wiley and Sons Inc., 1984.
- W. E. Boyce & R. C. Di Prima, Elementary Differential Equations and Boundary Value Problems, John Wiley and Sons Inc., 2009.
- P. Hartman, Ordinary Differential Equations, John Wiley & Sons, 1982.

Course No: 3	**Course Name:** Mathematical Modelling							**Course Code:** BMAE 0004
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VII	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week:4**
			3	1	0	0	4	**Total Hours: 40**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Ordinary and Partial Differential equations **Nature of Course:** Elective						

Course Objective	This course provides introduction of mathematical modeling and analysis in biological sciences. The major content of this course is chosen from population dynamics. This course covers the fundamentals of deterministic models in both discrete and continuous time domains. This course includes both linear and non-linear models with sufficient amount of theoretical background. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to: **CO1:** Understand the mathematical model and explain the series of steps involved in a mathematical modeling process. **CO2**: Apply the concept of mathematical modeling through difference equations in discrete time linear and discrete time nonlinear models. **CO3:** Use applications of mathematical modeling and make students appreciate the power and limitations of mathematics in solving practical real-life problems. **CO4:** Apply mathematical modeling in continuous time models.

COURSESYLLABUS

Module No.	**Content**	**Hours**
I	**[Course Outcome(s) No.: 1 and 2]** Overview of mathematical modeling, Types of mathematical models and methods to solve them, Discrete time linear models – Fibonacci rabbit model, Cell-growth model, Prey-predator model, Analytical solution methods and stability analysis of system of linear difference equations, Graphical solution – Cobweb diagrams, Discrete time age structured model – Leslie Model, Jury's stability test. Discrete time non-linear models-Different cell division models, Prey-predator model, Stability of non-linear discrete time models, Logistic difference equation.	20
II	**[Course Outcome(s) No.: 3 and 4]** Introduction to continuous time models – Limitations and Advantage of discrete time model, Need of continuous time models, Continuous time models – model for growth of microorganisms, Chemostat, Stability and linearization methods for system of ordinary differential equations. Continuous time single species model – Allee effect, Qualitative solution of differential equations using phase diagrams, Continuous time models – Lotka-Volterra competition model, Prey predator models.	20

Text Books:

- J. N. Kapur, Mathematical Modelling, New Age International, 2015.
- M. M. Meerschaert, Mathematical Modelling, Academic Press, 2013.
- A. Rutherford, Mathematical Modelling Techniques. Courier Corporation, 2012.
- R. J. Elliott & P. E. Kopp, Mathematics of Financial Markets. Springer Verlag, 2018.

Reference Books:

- L. D. Clive, Principles of Mathematical Modelling, Elsevier, 2004.
- E. A. Bender, An Introduction to Mathematical Modelling, Courier Corporation, 2000.

Course No: 4	**Course Name:** Operational Research-I							**Course Code:** BMAE 0005
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VII	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 4**
			3	1	0	0	4	**Total Hours: 40**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Operations Research **Nature of Course:** Elective						

Course Objective	This course will develop a profound understanding of linear and integer linear programming problems. The students will learn optimal decision policy and will be able to solve multistage decision problems. Further, a deep understanding of non-linear programming problems will be developed in this course. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to **CO1:** Solve various linear programming problems. **CO2:** Find solution of integer linear programming and sequencing problems. **CO3:** Learn the mathematical tools to solve problems on dynamic programming. **CO4:** Understand nonlinear programming problems and methods to obtain their solutions.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** **Linear Programming Problems (LPP):** Introduction, Simplex method, Duality, Dual simplex method, Sensitivity analysis. **Integer Linear Programming Problems:** Introduction, mixed integer programming problems, cutting plane method, Branch and bound method. **Sequencing Problem:** Introduction, Assumptions, Johnson's procedure for njobs on two machines and n jobs on m machines, 2 jobs through m machines, Travelling salesman problem.	20
II	**[Course Outcome(s) No.: 3 and 4]** **Dynamic Programming:** Introduction, Terminology, Optimal decision policy, Bellmann principle of optimality, Multistage decision problems, Programming under certainty, Approach for solving LPP. **Non Linear Programming Problems (NLPP):**Introduction, Formulation, Concave and Convex Functions, Solution of NLPP having one and more than one inequality constraints using Kuhn-Tucker conditions, Method of Lagrange multipliers.	20

Text Books:

- P. K. Gupta & D. S. Hira, Operations Research, S. Chand & Co., 2015.
- J. K. Sharma, Operations Research Theory and Applications, Macmillian India Ltd., 2017.
- K. Swarup, P. K. Gupta & M. Mohan, Operations Research, Sultan Chand & Sons, 2014.

Reference Books:

- S. D. Sharma, Operations Research, Kedar Nath Ram Nath Publications, 2012.
- H. A. Taha, Operations Research: An Introduction, Pearson Education, 2014.
- D. C. Sanyal & K. Das, Linear programming and Game Theory, U. N. Dhur & Sons (P) Ltd., 2020.

Course No: 5	**Course Name:** Regression Analysis and Predictive Modelling							**Course Code:** BMAE 0006
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VII	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 4**
			3	0	2	0	4	**Total Hours: 40**
Total Evaluation Marks: 100		**Examination Duration:** Mid Term (2 hours), End Term (3 hours)						
Mid Term: 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Pre-requisite of course:** Nil						
		Nature of Course: Elective						

Course Objective	This course will develop a profound understanding of normed linear spaces. This course also includes bounded, unbounded and closed operators, orthonormal basis and their properties. Further, a deep understanding of standard theorems and their applications will be developed in this course. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to: **CO1:** Understand the concept of estimation of parameters in regression model. **CO2:** Apply and use Gauss-Markov theorem to obtain best linear unbiased estimates. **CO3:** Understand the Difference between R-Squared and Adjusted R-Squared and interpret them as a measure of goodness of fit. **CO4:** Apply tests for linear hyphothesis testing to determine the relationship between the response and predictor variables. **CO5:** Learn and apply methods for model adequacy checking. **CO6:** Understand different Scenarios and the approach adopted when the underlying assumptions of multiple linear regression model fails. **CO7:** Understand the type of heteroscedasticity present in the model and apply methods accordingly. **CO8:** Understand the problem of multicollinearity and how to deal with it.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2, 3 and 4]** Multiple linear regression model and assumptions, estimation of parameters, estimable functions, error and estimation space, Gauss-Markov theorem, use of g-inverse. Model in deviation form, ANOVA for linear model, R^2, adjusted R^2 and other model selection criterion, tests of linear hypothesis, forecasting. Model Adequacy Checking: checking of linear relationship, residual analysis and scaling of residuals, regression variable hull, PRESS residuals, R-student residuals, residual plots, partial residual plots, detection and treatment of outliers, Diagnostics for leverage and influence, measures of influence.	20
II	**[Course Outcome(s) No.: 5, 6, 7, and 8]** Estimation of parameters by generalized least squares (GLS) in linear models with non-spherical disturbances, Gauss Markov theorem for GLS estimator, estimation under heteroscedasticity and tests of heteroscedasticity, tests for autocorrelation, estimation and forecasting under autocorrelated disturbances. Generalized Linear Models: Logistic Regression, Poisson Regression and Generalized Linear model. Multicollinearity: Introduction, sources of multicollinearity, effects of multicollinearity, variance Inflation factors (VIF), Methods of dealing with multicollinearity, Ridge Regression.	20

Text Books:

- N. R. Draper & H. Smith, Applied Regression Analysis, Wiley, 1998.
- J. Johnston, Econometric Methods, McGraw Hill, 1984.
- D. C. Montgomery, E. A. Peck & G.G. Vining, Introduction to Linear Regression Analysis, Wiley, 2006.

Reference Books:

- C. R. Rao, H. Toutenburg, Shalabh, C. Heumann & M. Schomaker, Linear Models and Generalizations-Least squares and alternatives, Springer, 2007.
- J. F. Monahan, A Primer on Linear Models, CRC Press, 2008.
- A. I. Khuri, Linear Model Methodology, CRC Press, 2010.
- G. A. F. Seber & A. J. Lee, Linear Regression Analysis, Wiley, 2003.

Course No: 6	**Course Name:** Coding Theory							**Course Code:** BMAE 0007
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VII	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 4**
			3	1	0	0	4	**Total Hours: 40**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Algebra **Nature of Course:** Elective						

Course Objective	This course will develop a profound understanding of linear codes, encoding and decoding of linear codes and their applications. Further, a deep understanding of cyclic, BCH and quaternary linear codes, and their advantages in finding the solution of mathematical problems will be developed in this course. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to **CO1**: Calculate the parameters of given codes and their dual codes using standard matrix and polynomial operations. **CO2:** Encode and decode information by applying algorithms associated with well-known codes. **CO3**: State and prove the fundamental theorems about error-correcting codes. **CO4:** Compare the error-detecting/correcting facilities of given codes for a given binary symmetric channel. **CO5:** Design simple linear or cyclic codes with required properties. **CO6:** Solve mathematical problems involving error-correcting codes by linking them to concepts from elementary number theory, combinatorics, linear algebra, and elementary calculus.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1 and 2]** **Linear Codes**: Brief introduction to coding theory, Linear codes, Hamming weight, Hamming code, Bases for linear codes, Generator matrix and Parity-check matrix, Equivalence of linear codes, Encoding with a linear code, Decoding of linear codes, Cosets, Nearest neighbor decoding for linear codes, Syndrome decoding, Golay code, Reed-Solomon code.	20
II	**[Course Outcome(s) No.: 3, 4, 5 and 6]** **Cyclic codes**: Definition of cyclic codes, Generator polynomials, Generator and parity-check matrices, Decoding of cyclic codes, Burst-error-correcting codes, BCH codes, Parameters of BCH codes, Decoding of BCH codes, Quaternary linear codes and their generator matrices.	20

Text Books:

- S. Ling S. & C. P. Xing: Coding Theory: A First Course, Cambridge University Press, 2004.
- D. R. Hankerson, D. G. Hoffman, D. A. Leonard, C. C. Lindner, K. T. Phelps, C. A. Rodger & J. R. Wall, Coding Theory and Cryptography: The Essentials, CRC Press, 2000.

Reference Book:

- Z. X. Wan: Quaternary Codes, World Scientific, Publishing Company Pvt. Ltd., 1997.

Course No: 7	**Course Name:** Topology							**Course Code:** BMAC 0010
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** VIII	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 5**
			4	1	0	0	5	**Total Hours: 50**

Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks	**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Real Analysis **Nature of Course:** Major – 1 Course

Course Objective	This course will develop a profound understandingof topological spaces, continuous functions and metrizable spaces. Further, a deep understanding of connected, compact and countability axioms and separation axioms will be developed in this course. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to: **CO1:** Understand topology, topological spaces and topology generated by basis and sub basis. **CO2:** Determine the nature of different points of a set. **CO3:** Learn continuous maps and understand product, quotient and metric topologies. **CO4:** Characterize the connected, compact and countable spaces. **CO5:** Know separation axioms and basic properties.

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 3]** Topological spaces, Basis and Sub basis, Ordered topology, Limit points, Adherent points, Isolated points, Derived sets, Dense sets, Closure, Interior, Exterior and Boundary points of a set, Subspaces, Continuity and Related results, The Pasting lemma. Homeomorphism, Product topology, Product of topological spaces, Metric topology, Metrizable space, Quotient topology.	25
II	**[Course Outcome(s) No.: 4 and 5]** Connected and Disconnected spaces, Components, Path connected spaces, Path components, totally disconnected spaces, locally connected spaces. Compact spaces, Limit point compact and sequentially compact spaces, Local compactness, First and Second countable spaces, Separable space, Separation axioms: T_0, T_1, T_2, T_3,$T_{3^{1/2}}$, T_4 spaces, Characterizations and basic properties.	25

Text Books:

- J. R. Munkres, Topology, A First Course, PHI, 2000.
- G. F. Simmons, Introduction to Topology and Modern Analysis, TMH, 1963.
- J. N. Sharma & J. P. Chauhan, Topology (General and Algebraic), Krishna Prakashan, 2019.

Reference Books:

- J. L. Kelley, General topology, Springer Verlag, 2017.
- K. D. Joshi, An introduction to general topology, Wiley Eastern Ltd., 2017.

Course No: 8	**Course Name:** Functional Analysis							**Course Code:** BMAC 0011
Batch: 2024-2028	**Programme:** B. Sc. Mathematics (With specialization in Data Science)	**Semester:** II	**L**	**T**	**P**	**J**	**Credits**	**Contact Hrs Per Week: 5**
			4	1	0	0	5	**Total Hours: 50**
Total Evaluation Marks: 100 **Mid Term:** 30 Marks **End Term:** 50 Marks **Internal Assessment**: 20 Marks		**Examination Duration:** Mid Term (2 hours), End Term (3 hours) **Pre-requisite of course:** Linear Algebra **Nature of Course:** Major – 1 Course						

Course Objective	This course will develop a profound understanding of normed linear spaces. This course also includes bounded, unbounded and closed operators, orthonormal basis and their properties. Further, a deep understanding of standard theorems and their applications will be developed in this course. This course focuses on employability and skill development aligned with all CO's.
Course Outcomes	After studying these topics, the students will be able to: **CO1:** Understand Banach and Hilbert spaces, and standard theorems defined on these spaces **CO2:** Differentiate bounded, unbounded and closed operators **CO3:** Check convergence of operators by using a suitable norm and compute the dual spaces **CO4:** Find orthonormal basis and learn its applications **CO5:** Apply uniform boundedness theorem, open mapping theorem and closed graph theorem

COURSE SYLLABUS

Module No.	Content	Hours
I	**[Course Outcome(s) No.: 1, 2 and 3]** Normed linear spaces, Banach spaces, Hilbert Spaces and basic properties, Heine Borel theorem, Riesz lemma and best approximation property, Inner product spaces, Projection Theorem, Bounded operators, Space of bounded operators, unbounded operators, Riesz representation theorem, Convergence of sequence of operators, Closed operator	25
II	**[Course Outcome(s) No.: 4 and 5]** Orthonormal bases, Bassel inequality and Parseval's Formula, Riesz Fischer theorem, Hahn Banach extension theorem, Uniform boundedness principle, Closed graph theorem and Open mapping theorem, Applications.	25

Text Book:

- M. T. Nair, Functional Analysis, A first course, PHI, 2001.
- B. V. Limaye, Functional Analysis, New Age International, 2014.
- G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, Inc. 2017.

Reference Books:

- E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons, 2007.
- A. H. Siddiqi, K. Ahmad & P. Manchanda, Introduction to Functional Analysis with Applications, Anamaya Publishers, 2007.
- G. Bachman & L. Narici, Functional Analysis, Courier Corporation, 2012.
- J. B. Conway, A Course in Functional Analysis. Springer, 2010.