HSNC University Mumbai

(2024-2025)

Ordinances and Regulations

With Respect to

Choice Based Credit System

(CBCS)

For the Programmes Under

The Faculty of Science and Technology

For the Course

MATHEMATICS

Semester III , Semester -IV
With effect from the Academic year 2024-2025

under NEP 2020

Board of Studies in Mathematics

1. **Name of Chairperson**
   Mrs. Usha G. Hemasundar ,Head, Department of Mathematics, M Sc Mathematics Associate Professor, K. C. College Ph: 9892234921 Email id: usha.gollakota@kccollege.edu.in

   Name of Co-Chairperson
   Ms. Shubhada Kanchan, MSc Mathematics,Department of Mathematics and Statistics Assistant Professor, H. R. College,Ph: 9975673087 Email id: shubhadark@yahoo.co.in

2. **Two to five teachers each having minimum five years teaching experience amongst the full-time teachers of the Departments, in the relevant subject.**
   a.) Dr. Pankit Gandhi, MSc (Mathematics), M Phil, Ph.D., LL.B., Associate Professor, K. C. College, Ph: 8169381936 Email id: pankit.gandhi@kccollege.edu
   b.) Mrs. Vijayalaxmi Suvarna ,M Sc Mathematics, M.Phil ,Assistant Professor,H. R. College, Ph: 9987395783; Email id: vijayalaxmi_suvarna@rediffmail.com
   c.) Mrs. Mrunal Hardikar ,M Sc Mathematic, Assistant Professor, K. C. College, Ph: 9653227252; Email id: mrunal.hardikar@kccollege
   d.) Mr. Nilesh Bhandarkar ,M Sc Mathematic, Assistant Professor, K. C. College, Ph: 98200868037; Email id:nilesh.bhandarkar@kccollege

3. **One Professor / Associate Professor from other Universities or professor / Associate Professor from colleges managed by Parent Body; nominated by Parent Body;-**
   a.) Dr Sushil Kulkarni , Professor, Head, School of Mathematics,Applied Statistics &Analyticas,NMIMS
4. **External experts from Industry / Research / eminent scholar in the field relevant to the subject nominated by the Parent Body**;
   a.) Dr Ajit Kumar , Ph.D. Mathematics,Associate Professor and Head, Department of Mathematics, Institute of Chemical Technology, Mumbai
   b.) Mrs. Jayashree Shetty, Associate Professor, KPB Hinduja College, Mumbai
   c.) Dr. Amiya Ranjan Bhowmick, Ph.D. Applied Mathematics and Statistics; Assistant Professor, Institute of Chemical Technology, Mumbai
   d.) Mr. Prashant Shukla,MSc statistics, Masters in Financial Management JBIMS; Chief Investment Officer, Aston Capital Advisor Pvt Ltd,Partner at HBD Consulting LLP
   e.) Mr. Nikunj Sharma ,Zonal Head, Tata Portfolio JLL,
   f.) Mr. Kaushal Shah,M.Com, PGDBA(Finance),Senior Manager, Treasury Reliance Power
   g.) Mr. Ravi Vyas ,Founder S.MONK School of Actuaries
5. **Top rankers of the Final Year Graduate and Final Year Post Graduate examination of previous year of the concerned subject as invitee members for discussions on framing or revision of syllabus of that subject or group of subjects for one year.**

   Ms. Gunjan Shinde, B Sc, Mathematics, Currently pursuing online Degree in data Science and Programming from IIT ,Madras.

Preamble

The syllabus for major and minor courses in Mathematics are designed to lay a solid foundation for the undergraduate Mathematics student (Science Stream) in the two core aspects of Mathematics; viz the discrete and the continuous.

Discrete Mathematics involves the study of discrete objects; i.e. objects which are finite or can be enumerated by integers. It plays a foundational role in other branches of mathematics such as Number Theory, Linear Algebra, Abstract Algebra, Combinatorics, Graph Theory and Probability Theory. It also provides the mathematical foundation for many computer science courses such as data structures, automata theory, and compiler theory and computer security. The applications of Discrete Mathematics are spread across diverse areas such as Chemistry, Life Sciences, Business and Data Analysis.

While discrete means separate or distinct, continuous means without interruption or breaks. Continuous Mathematics provides excellent tools for analyzing real world phenomena that change smoothly over time. Traditional Geometry, Calculus, Real and Complex Analysis, Differential Equations, Differential Geometry, Topology and Functional Analysis are some of the branches of Mathematics which come under the banner of Continuous Mathematics. It is useful in the fields of Physics, Statistics, Economics, Finance, Artificial Intelligence, Biotechnology and Engineering.

A student who completes the minor course in Mathematics will be well equipped to understand the foundational concepts of Discrete Mathematics, Calculus and Linear Algebra which are applicable to other branches of sciences and humanities.
In addition, a student who completes the major course in Mathematics will enhance their knowledge in Pure Mathematics and develop their analytical thinking ability.

Curriculum Topics along with Self-Learning Topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT.
The course will be conducted through the medium of lectures along with practical /lab sessions. The course assessment will include team presentations/home assignment based on self-learning topics (SLE) as well as traditional semester end written examination.

Part1: Detail Scheme Theory

The Scheme of Teaching and Examination

For Mathematics Major

Semester – III

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

S. N.	Choice Based Credit System	Subject Code	Remarks
1	Mathematics I (**Title**: MAJOR I: Univariate Calculus)	MAT201B	Offered to Mathematics Major students only
2	Practical based on Univariate Calculus	MAT201D	Offered to Mathematics Major students only
3	Mathematics II (**Title**: MAJOR II: Linear Algebra I)	MAT202B	Offered to Mathematics Major students only
4	Practical based on Linear Algebra – I	MAT202D	Offered to Mathematics Major students only
5	SEC: Mathematical and Software Skills for Finance I	MAT201C	Offered to Mathematics Major students only
6	Practical based on Mathematical and Software Skills for Finance I	MAT207D	Offered to Mathematics Major students only

Detail Scheme: For Mathematics Major

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme				Total Marks
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	MAT201B	MAJOR I: Univariate Calculus	3	20% *	3	0	0	3	15	-	-	60	75
2	MAT201D	Practical sessions based on Univariate Calculus	1		0	0	1	1	-	-	-	25 (Practical Examination)	25
3	MAT202B	MAJOR II: Linear Algebra I	3	20% *	3	0	0	3	15	-	-	60	75

4	MAT202D	Practical sessions based on Linear Algebra I	1		0	0	1	1	-	-	-	25 (Practical Examination)	25
5	MAT201C	SEC: Mathematical and Software Skills for Finance I	2	-		0	0	2	-	-	-	50	50
6	MAT207D	Practical sessions based on Mathematical and Software Skills for Finance I	1		0	0	1	1	-	-	-	25 (Practical Examination)	25
	Total Hours / Credit							11	Total Marks				275

- **Lecture Duration – 60 Minutes = 1 Hour**
- **One Credit Theory= 15 Hours**
- **One Credit Practical= 30 Hours**

L: Lecture P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self-learning evaluation OBT -Open Book Test, SEE- Semester End Examination, PA-Project Assessment, AT- Attendanc

Title of course: MAJOR-I: Univariate Calculus

Total credits: 04 (3T+ 1P)

Semester – III Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT201B	I	Real Number System	15	45 L	3	75 (60+15)
		II	Sequences of Real Numbers	15			
		III	Ordinary Linear Differential Equations	15			
2	MAT201D		Practical Sessions Based on Univariate Calculus	30	30	1	25
			TOTAL			4	100

Salient Features:

- In Unit 1, we focus on important concepts of the real number system which forms the base for Abstract Mathematical theories.
- In Unit 2, we introduce the concept of sequences of real numbers.
- In Unit 3, we focus on key concepts and methods of higher order ordinary differential equations. Differential equations play a fundamental role in modern science where a differential equation is formulated to describe how a physical system changes in time. Applications of differential equations are found in Physics, Engineering, Chemistry, Biology, Economics and Finance.

Learning Objectives:

1. To introduce the learner with important concepts of the real number system which forms the base for Abstract Mathematical theories.
2. To introduce the concept of sequences of real numbers.
3. To understand concepts and methods of higher order ordinary differential equations which are useful in other sciences.
4. To emphasize on understanding proofs, appreciate the language of proofs and develop mathematical-writing skills.

Course Outcomes: After completing this course,

1. Learner will be able to appreciate the axiomatic approach used in developing the mathematical theories of the real number system. This will enable the learner to understand and appreciate other mathematical structures to which he shall be introduced to in the higher semesters.
2. Learner will be able to understand and apply pure mathematical definitions and concepts.
3. Learner will be able to find solutions of linear differential equations of higher order.

Evaluation Pattern:

The course will be assessed for a total of 100 marks and will consist of:

- **Summative Assessment** (End Semester Theory Exam): **60 marks**.
  Paper Pattern:

Q1: **Unit 1**: (15 marks)

A) Attempt any one out of two (7 marks each)
B) Attempt any two out of three (4 marks each)

Q2: **Unit 2**: (15 marks)

A) Attempt any one out of two (7 marks each)
B) Attempt any two out of three (4 marks each)

Q3: **Unit 3**: (15 marks)

A) Attempt any one out of two (7 marks each)
B) Attempt any two out of three (4 marks each)

Q4: **All three units**: (15 marks)

A) Attempt any five out of seven (3 marks each)

- **Formative Assessment: 40 marks.**

(Self-Learning Evaluation – 15 marks (assignment or group project) and Practical Exam – 25 mark

(Self-Learning Evaluation – 15 marks comprising of

- class assignment or home assignment or a case study or Group Presentation on SLE Topics (10 marks)
- Viva based on sle topics (5 marks)

Course Code: MAT201B

Unit	Content	No. of Lectures
1	**1. Real Number System** 1.1. The Algebraic and Order properties of $\mathbb{R}$, Absolute value and its properties. 1.2. AM-GM inequality, Cauchy-Schwarz inequality, Intervals, and neighborhoods, Hausdorff property. 1.3. Bounded sets, Least upper bound (Supremum) and Greatest lower bound (infimum) of subsets of IR, Maximum and minimum, *l*.u.b. axiom (Order Completeness axiom) and its consequences. 1.4. Archimedean property and its applications, The Density Theorem. Nested Interval Property(Statement),Applications.	**15**
2	**2. Sequences of Real numbers** 2.1. Sequence, convergence of sequence ,evaluating limit of a sequence using limit definition , bounded sequence ,relation between convergent sequence and bounded sequence, Limit of a convergent sequence and uniqueness of limit, Divergent sequences. 2.2. Convergence of standard sequences like $\left(\frac{1}{1+na}\right) \forall\ a > 0$, ($b^n$) for all $0 < b < 1$, $\left(c^{\frac{1}{n}}\right) \forall\ c > 0$ & $\left(n^{\frac{1}{n}}\right)$. Algebra of convergent sequences, Sandwich (Squeeze) theorem of sequences. 2.3. Monotone sequences, monotone convergence theorem 2.4. Subsequences, Cauchy Sequences	**15**
3	**3. Ordinary Linear Differential Equations:** **3.1** Higher order Linear Differential Equation, Second order linear Differential Equations, Uniqueness Theorem for the	

	solution of a second order initial value problem (statement only),Wronskian and linear independence of the solutions. Homogeneous and non-homogeneous second order linear differentiable equations. The General Solution of the second order Homogeneous Equation, The Use of a Known Solution to find Another solution of the Homogeneous second order Differential Equation. The general solution of a non-homogeneous second order equation:Complementary functions and particular integrals. **3.2** The second order homogeneous linear differential equation with constant coefficients, auxiliary equation and general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation. The general solution of Higher order homogeneous linear differential equations with constant coefficients, the auxiliary equations, Roots of the auxiliary equations: real and distinct, real and repeated, complex and complex repeated. **3.3** The method of undetermined coefficients (UDC) to find particular Integral for non-homogeneous second order linear differential equation . The method of undetermined coefficients(UDC) to find particular Integral for non-homogeneous higher order linear differential equation . **3.4** The method of variation of parameter Method to find particular Integral for non-homogeneous second order linear differential equation	**15**

Practicals based on MAJOR-I: Univariate Calculus

Course Code:MAT201D

(15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	P1 to P4: Practicals based on 1.1 to 1.4 **P5 to P8: Practicals based on 2.4 to 2.4** **P9 to P12: Practicals based on 3.1 to 3.4** **P13 to P15: Practicals reserved for revision and extra practice.**	30

Self-Learning topics (Unit wise)

Unit	**Topics**
1	1.2AM-GM inequality, Cauchy-Schwarz inequality, Intervals
2	2.2$convergence\ of\ \left(c^{\frac{1}{n}}\right)\forall$ c > 0 &$\left(n^{\frac{1}{n}}\right)$.
3	3.3 Higher order homogeneous linear differential equations with constant coefficients, the auxiliary equations, Roots of the auxiliary equations: real and distinct, real and repeated ,complex and complex repeated.

	3.4 The method of undetermined coefficients(UDC) / short UDC Methods to find particular Integral for non-homogeneous higher order linear differential equation

1.Basic Real Analysis' **by Prof. I K Rana , IIT Mumbai** https://nptel.ac.in/courses/111/101/111101134/ lectures ,3,4,5,6

Reference Books

1. A Basic Course in Real Analysis, Ajit kumar, S. Kumaresan, CRC Press, 2014.
2. Introduction to Real Analysis, John Wilely & Sons, 1994 by.R. G. Bartle-D. R. Sherbert,
3. Differential equations with applications and historical notes, by G. F. Simmons, McGraw Hill
4. Ordinary and Partial Differential Equations, M.D. Raisinghania, S. Chand

Title of course: Title of course: Major II: Linear Algebra-I

Total credits: 04 (3T+ 1P)

Semester – III Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT201B	I	**Vectors**	15	45 L	3	75 (60+15)
		II	System of linear equations.	15			
		III	Matrix and Matrix Algebra.	15			
2	MAT201D		Practicals based on Linear Algebra-I	30	30	1	25
			TOTAL			4	100

Objective:

The objective of the course is to introduce the student to the subject of Linear Algebra and to lay a strong foundation for further study in the subject.

Learning Objectives:

1. To introduce the learner to the concepts of
   - scalars and vectors and generalize the same
   - linear combination of vectors
   - inner product and orthogonality.
   - system of linear equations
   - matrix representation of system of linear equations
   - Elementary Row Operations
   - Row equivalent matrices

- Row echelon form
- Row reduced row echelon form.
- Matrix types and Matrix operations
- Invertible matrix. Properties.
- Elementary matrices

2. To study the applications of above concepts to
   - The geometric entities of lines and planes.
   - Gaussian elimination and Gauss-Jordan elimination methods.
   - Finding the inverse of an invertible matrix.

Course Outcomes: After completing this course,

1. The learner will be able to apply the above concepts to find equations of lines and planes.
2. The Learner will be able to solve system of equations using Gauss and Gauss-Jordan elimination methods.
3. The Learner will be able to find the inverse of a matrix.

Evaluation Pattern:

The course will be assessed for a total of 100 marks and will consist of:

- **Summative Assessment** (End Semester Theory Exam): **60 marks**.
  Paper Pattern:

Q1: **Unit 1**: (15 marks)

A) Attempt any one out of two (7 marks each)
B) Attempt any two out of three (4 marks each)

Q2: **Unit 2**: (15 marks)

A) Attempt any one out of two (7 marks each)
B) Attempt any two out of three (4 marks each)

Q3: **Unit 3**: (15 marks)

A) Attempt any one out of two (7 marks each)
B) Attempt any two out of three (4 marks each)

Q4: **All three units**: (15 marks)

Attempt any five out of seven (3 marks each)

- **Formative Assessment:**

(Self-Learning Evaluation – 15 marks comprising of

- Group Presentation on SLE Topics (10 marks)
- Viva Voce (5 marks)

Course II: Title of course: Major II: Linear Algebra-I

Course Code: MAT202A

Total credits: 3

Unit	Content	No. of Lectures
1	**Unit I: Vectors.** 1.1 Scalars and Vectors, Vectors in $\mathbb{R}^2$ /$\mathbb{R}^3$. Generalization to $\mathbb{R}^n$, 1.2 Linear combination of vectors. 1.3 Inner product and orthogonality 1.4 Lines and planes.	**15**
2	**Unit II: System of linear equations.** 2.1 System of Linear Equations. Matrix Representation. 2.2 Elementary Row Operations (ERO). Row equivalent matrices. 2.3 Row echelon form (REF) and reduced row echelon form (RREF). 2.4 Gaussian elimination and Gauss-Jordan elimination methods.	**15**
3	**Unit III: Matrix and Matrix Algebra**. 3.1 Matrix types and Matrix operations, Properties. 3.2 Invertible matrix. Properties. 3.3 Elementary matrices. Properties. 3.4 Finding the inverse of an invertible matrix.	**15**

Practicals based on Linear Algebra-I

Course Code:MAT201D

(15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	P1 to P4: Practicals based on 1.1 to 1.4 **P5 to P8: Practicals based on 2.4 to 2.4** **P9 to P12: Practicals based on 3.1 to 3.4** **P13 to P15: Practicals reserved for revision and extra practice.**	30

Self-Learning topics (Unit wise)

Unit	Topics
1	1.1 Scalars and Vectors, Vectors in $\mathbb{R}^2$ /$\mathbb{R}^3$. Generalization to $\mathbb{R}^n$. 1.4 Lines and planes.
2	2.1 System of Linear Equations. Matrix Representation.
3	3.1 Matrix types and Matrix operations, Properties.

Online Resources

1. Online book on "Linear Algebra with Sage" with Sang-Gu Lee and others. **2.** Online Reference (For Practical) https://ajitmathsoft.wordpress.com/sagemath/

3. Basic Linear Algebra By Prof. I. K. Rana, IIT Bombay available on NPTEL portal at https://onlinecourses.nptel.ac.in/noc20_ma08/preview **4. Linear Algebra Co-ordinated by IIT Kanpur, available on NPTEL portal at** https://nptel.ac.in/courses/111/104/111104137/ Subject to change if any new relevant course is available.	

Reference Books:

1. Big-Book-LinearAlgebra-Eng-2015, by Kyobobook (ISBN-978-89-24-03105-8)
2. A First Course in Linear Algebra, by Robert A. Beezer, Version 3.50 (Created: 2015-12-30T15:06:58-08:00; Technical Refresh: 2017-04-14)
3. Elementary Linear Algebra, by Howard Anton, WileyPlus, 11th Edition 2019 (ISBN-978-1-119-62569-8)
4. Linear Algebra: A Geometric Approach by S. Kumaresan, Prentice Hall of India, 2000.
5. Linear Algebra and its Applications, by Gilbert Strang, Thomson Learning Inc., 1988.

N.B.: The use of CAS SageMath to solve problems will be demonstrated and encouraged during Practicals in addition to the traditional problem-solving methods.

Skill Enhancement Course

Total credits: 03 (2T+ 1P)

Semester – III Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT201C	I	**Deterministic Cash Flows**	15	30 L	2	50
		II	**Random Cash Flows**	15			
2	MAT207D		Practical Sessions Based on SEC: Mathematical and Software Skills for Finance I	30	30	1	25
			TOTAL			3	75

Learning Objectives:

1. This course is designed to make learners aware of financial literacy and to understand applications of simple mathematical concepts in finance.
2. In a practical component of this course, learners will be introduced to various libraries (NumPy, Matplotlib) in Python for designing, visualizing and solving financial problems.

Learning Outcomes:

1. After completing this course, learners will be able to calculate rate of returns and present value analysis of investments in risk-free assets.
2. After completing this course, learners will be able to evaluate risk and returns on portfolios with risky assets.
3. This course will enhance students' awareness of financial literacy and help them understand the applications of simple mathematical concepts in finance.

4. Learners will be able to use mathematical techniques to design solutions to financial problems and solve, and visualize using various libraries in Python. (NumPy, Matplotlib, Pandas)

Evaluation Pattern:

The course will be assessed for a total of 75 marks and will consist of:

- **Summative Assessment** (End Semester Theory Exam): **50 marks**.

  Paper Pattern:

Q1: **Unit 1**: (20 marks) Attempt any four out of five (5 marks each) Q2: **Unit 2**: (20 marks) Attempt any four out of five (5 marks each) Q3 **Both Units**: (10 marks) Attempt any five out of six (2 marks each)

- **Formative Assessment: 25 marks.**

Practical Exam – 50 marks to be converted into 25.

Course Code: MAT201C
Course Title: SEC: Mathematical and Software Skills for Finance I

Unit	Content	No. of Lectures
1	**1. Deterministic Cash Flows** 1.1 Concept of an investment, Types of investments, Interest rates and future value of money, rate of return. 1.2 Net present value and internal rate of return. 1.3 Annuities, amortization and continuous compounding. 1.4 Cash flows and Present value analysis. 1.5 Bonds: Price and Yield.	**15**
2	**2. Random Cash Flows** 1.1 Concept of risky assets, Shares and Mutual funds. 1.2 Expected return and variance as a measure of risk, No arbitrage principle. 1.3 Portfolio (as a vector), concept of expected return and risk of a portfolio, concept of short selling. 1.4 Binomial tree model. 1.5 Generalized n-step model and risk neutral probability.	**15**

MAT207D

Practical Sessions Based on SEC: Mathematical and Software Skills for Finance

I

(15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	3.1 Rate of return using Python. **3.2 Present Value Analysis.** **3.3 Designing Interest compounding calculator in Python.** **3.4 Accumulated and present value of ordinary, simple and Certain annuities** **3.5 Block annuity and Annuity payout calculations.** **3.6 Amortization of loans, Designing amortization table.** **3.7 Balloon loans as general annuity.** **3.8 Refinancing a loan, loan refinancing calculator.** **3.9 Schedule for a bond.** **3.10 Dirty price of a bond, graphs of clean bond prices and dirty bond prices over time.** **3.11 Computing the Yield given the bond price.** **3.12 Introduction to Capital Budgeting, NPV, Computations of Capital Budgeting using MS Excel.** **3 Practical sessions are reserved for revision and extra practice.**	30

Unit	Topics
1	Bonds: Price and Yield.
2	Generalized n-step model and risk neutral probability.

Online Resources

*Subject to change if any new relevant course is available.

NPTEL :: Mathematics - NOC:Mathematical Portfolio Theory by Prof. Siddhartha Pratim Chakrabarty, Department of Mathematics IIT Guwahati (Lectures 4 and 5)

Reference Books:

1. An Elementary Introduction to Mathematical Finance, Third Edition by Sheldon M. Ross, Cambridge University Press.
2. The Calculus of Finance by Amber Habib, University Press.
3. Mathematics for Finance: An Introduction to Financial Engineering by Amrek Capinski and Tomasz Zastawniak, Springer.
4. Financial Mathematics with Python: A Concise Guide by Stephen Fratini, Kindle book.

Part 2

The Scheme of Teaching and Examination
Semester – III

For Mathematics Minor

Sr. No.	Choice Based Credit System	Subject Code	Remarks
3	Mathematics II (**Title**: MINOR : Linear Algebra I)	MAT203B	Offered to Mathematics Major students only
4	Practical based on Linear Algebra – I	MAT203D	Offered to Mathematics Major students only

Detail Scheme: For Mathematics Minor

S. No.	Course Code	Course Title	Periods Per Week				Credit	Total Marks			
			Units	L	T	P		SLE	SEE	Practical Exam	Total
1	MAT203B	MINOR: Linear Algebra I	3	**0**			**3**	15	60		**75**
2	MAT203D	Practical sessions based on Linear Algebra I	1			**2**	**1**		**25**	**25**	**25**

One to two lectures to be taken for CONTINUOUS self-learning Evaluation

Second Year Semester – III

Course II: Course Code:
Title of course: Minor Linear Algebra-I **Total credits: 2+1**

Semester – III Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT201B	I	**Vectors**	15	45 L	3	75 (60+15)
		II	System of linear equations.	15			
		III	Matrix and Matrix Algebra.	15			
2	MAT201D		Practicals based on Linear Algebra-I	30	30	1	25
			TOTAL			4	100

Objectives:
The objective of the course is to introduce the student to the subject of Linear Algebra and to lay a strong foundation for further study in the subject.

Learning Objectives:

3. To introduce the learner to the concepts of

- scalars and vectors and generalize the same
- linear combination of vectors
- inner product and orthogonality.
- system of linear equations
- matrix representation of system of linear equations
- Elementary Row Operations
- Row equivalent matrices
- Row echelon form
- Row reduced row echelon form.
- Matrix types and Matrix operations
- Invertible matrix. Properties.
- Elementary matrices

4. To study the applications of above concepts to
   - the geometric entities of lines and planes.
   - Gaussian elimination and Gauss-Jordan elimination methods.
   - Finding the inverse of an invertible matrix.

Learning Outcomes: After completing this course,

1. Learner will be able to apply above concepts to find equations of lines and planes.
2. Learner will be able to solve system of equations using Gauss and Gauss-Jordan elimination methods.
3. Learner will be able to find inverse of a matrix.

Evaluation Pattern:

The course will be assessed for a total of 100 marks and will consist of:

- **Summative Assessment** (End Semester Theory Exam): **60 marks**.
  Paper Pattern:

Q1: **Unit 1**: (15 marks)

A) Attempt any three out of five (2 marks each)
B) Attempt any three out of five (3 marks each)

Q2: **Unit 2**: (15 marks)

A) Attempt any three out of five (2 marks each)
B) Attempt any three out of five (3 marks each)

Q3: **Unit 3**: (15 marks)

A) Attempt any three out of five (2 marks each)
B) Attempt any three out of five (3 marks each)

Q4: **All three units**: (15 marks)

A) Attempt any three out of five (5 marks each)

- **Formative Assessment: 40 marks.**

(Self-Learning Evaluation – 15 marks comprising of
- Group Presentation on SLE Topics (10 mks)
- Viva Voce (5 mks)

Unit	Content	No. of Lectures
1	**Unit I: Vectors.** 1.5 Scalars and Vectors, Vectors in $\mathbb{R}^2$ /$\mathbb{R}^3$. Generalization to $\mathbb{R}^n$, 1.6 Linear combination of vectors. 1.7 Inner product and orthogonality 1.8 Lines and planes.	**15**
2	**Unit II: System of linear equations.** 2.4 System of Linear Equations. Matrix Representation. 2.5 Elementary Row Operations (ERO). Row equivalent matrices. 2.6 Row echelon form (REF) and reduced row echelon form (RREF). 2.4 Gaussian elimination and Gauss-Jordan elimination methods.	**15**
3	**Unit III: Matrix and Matrix Algebra**. 3.5 Matrix types and Matrix operations, Properties. 3.6 Invertible matrix. Properties. 3.7 Elementary matrices. Properties. 3.8 Finding the inverse of an invertible matrix.	**15**

Practicals based on Minor:Linear Algebra-I

Course Code:MAT203D

(15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	P1 to P4: Practicals based on 1.1 to 1.4 **P5 to P8: Practicals based on 2.4 to 2.4** **P9 to P12: Practicals based on 3.1 to 3.4** **P13 to P15: Practicals reserved for revision and extra practice.**	30

Self-Learning topics (Unit wise)

Unit	Topics
1	1.1 Scalars and Vectors, Vectors in $\mathbb{R}^2$ /$\mathbb{R}^3$. Generalization to $\mathbb{R}^n$. 1.4 Lines and planes.
2	2.1 System of Linear Equations. Matrix Representation.
3	3.1 Matrix types and Matrix operations, Properties.

Online Resources

1. Online book on "Linear Algebra with Sage" with Sang-Gu Lee and others.

2. Online Reference (For Practical) https://ajitmathsoft.wordpress.com/sagemath/

3. Basic Linear Algebra By Prof. I. K. Rana, IIT Bombay available on NPTEL portal at https://onlinecourses.nptel.ac.in/noc20_ma08/preview

4. Linear Algebra Co-ordinated by IIT Kanpur, available on NPTEL portal at https://nptel.ac.in/courses/111/104/111104137/

Subject to change if any new relevant course is available.

Reference Books:

6. Big-Book-LinearAlgebra-Eng-2015, by Kyobobook (ISBN-978-89-24-03105-8)
7. A First Course in Linear Algebra, by Robert A. Beezer, Version 3.50 (Created: 2015-12-30T15:06:58-08:00; Technical Refresh: 2017-04-14)
8. Elementary Linear Algebra, by Howard Anton, WileyPlus, 11th Edition 2019 (ISBN-978-1-119-62569-8)
9. Linear Algebra: A Geometric Approach by S. Kumaresan, Prentice Hall of India, 2000.
10. Linear Algebra and its Applications, by Gilbert Strang, Thomson Learning Inc., 1988.

N.B.: The use of CAS SageMath to solve problems will be demonstrated and encouraged during Practicals in addition to the traditional problem-solving methods

Part 3

The Scheme of Teaching and Examination

For Mathematics Major

Semester – IV

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

S. N.	Choice Based Credit System	Subject Code	Remarks
1	Mathematics I (**Title**: MAJOR I: Infinite series and Riemann Integration)	MAT204B	Offered to Mathematics Major students only
2	Practical based on Infinite series and Riemann Integration	MAT204D	Offered to Mathematics Major students only
3	Mathematics II (**Title**: MAJOR II: Linear Algebra II)	MAT205B	Offered to Mathematics Major students only
4	Practical based on Linear Algebra – II	MAT205D	Offered to Mathematics Major students only
5	SEC: Mathematical and Software Skills for Finance II	MAT202C	Offered to Mathematics Major students only
6	Practical based on Mathematical and Software Skills for Finance II	MAT208D	Offered to Mathematics Major students only

Detail Scheme: For Mathematics Major

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme				Total Marks
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	MAT204B	MAJOR I: Infinite series and Riemann Integration	3	20% *	3	0	0	3	15	-	-	60	75
2	MAT204D	Practical sessions based on Infinite series and Riemann	1		0	0	1	1	-	-	-	25 (Practical Examination)	25

		Integration										
3	MAT205B	MAJOR II: Linear Algebra II	3	20% *	3	0	0	3	15	-	-	60	75
4	MAT205D	Practical sessions based on Linear Algebra II	1		0	0	1	1	-	-	-	25 (Practical Examination)	25
5	MAT202C	SEC: Mathematical and Software Skills for Finance II	2	-		0	0	2	-	-	-	50	50
6	MAT208D	Practical sessions based on Mathematical and Software Skills for Finance II	1		0	0	1	1	-	-	-	25 (Practical Examination)	25
	Total Hours / Credit							11	Total Marks				275

- **Lecture Duration – 60 Minutes = 1 Hour**
- **One Credit Theory= 15 Hours**
- **One Credit Practical= 30 Hours**

L: Lecture P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self-learning evaluation OBT -Open Book Test, SEE- Semester End Examination, PA-Project Assessment, AT- Attendanc

Title of course: MAJOR-I: Infinite series and Riemann Integration

Total credits: 04 (3T+ 1P)

Semester – III Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT204B	I	Infinite Series of real numbers	15	45 L	3	75 (60+15)
		II	Riemann Integration	15			
		III	Applications Of Integration	15			
2	MAT204D		Practical Sessions Based on Infinite series and Riemann Integration	30	30	1	25
			TOTAL			4	100

Learning Objectives:

5. To introduce the learner with important concepts of infinite series.
6. To introduce the concept of Riemann integration and fundamental theorem for integration and its applications.
7. To understand applications of integration which are useful in real life problems and other sciences.
8. To emphasize on understanding proofs, appreciate the language of proofs and develop proof writing skills.

Learning Outcomes: After completing this course,

4. Learner will be able to appreciate the axiomatic approach used in developing the mathematical theories of infinite series.
5. Learner will be able to understand and apply pure mathematical definitions and concepts of Riemann Integration.
6. Learner will be able to apply theories of mathematical problem solving using integration.

Objectives:

Unit	Content	No. of Lectures
1	**I. Infinite Series of real numbers** 1.1 Introduction to Infinite Series of real numbers, simple examples of series, The Sequence of partial sums of a series, convergent series, divergent series, Algebra of Convergent Series, Convergence of geometric series and p-series. 1.2 The nth term Test for series, Cauchy criterion, Cauchy's Condensation Test, divergence of harmonic series, convergence of p-series, 1.3 absolute convergence, conditional convergence. Abel's and Dirichlet's tests for conditional convergence of series 1.4 Comparison test, limit comparison test, D Alembert's Ratio test, Root test. Alternating series, Leibnitz's test for convergence of alternating series.	**15**

Unit	Content	No. of Lectures
2	**II. Riemann Integration** 2.1 Partition of closed and bounded interval, Upper and Lower Riemann sums, Refinement of a partition, and properties of upper, lower Riemann sums, Upper and Lower Riemann integrals,	**15**

	Definition of Riemann integral on a closed and bounded interval, Examples of R-integrable functions. 2.2 Criterion for Integrability, its Corollary and problems based on Criterion for Integrability. 2.3 Properties of Riemann Integral. 2.4 Indefinite Riemann integral, First and second Fundamental theorem of Calculus, Mean value theorem for integrals. Integration by parts, Change of variable formula.	
3	**III. Applications Of Integration** 3.1 Improper integrals-type 1 and type 2, Absolute convergence of improper integrals Comparison tests, Abel's and Dirichlet's tests for conditional convergence. 3.2 Beta, Gamma functions. Properties of Beta Gamma functions. 3.3 Applications of definite integral**:** Area between curves, finding volumes by slicing, volumes of solids of revolution-Disks and Washers, Cylindrical Shells, Lengths of plane curves, Areas of surfaces of revolution. 3.4 Approximate integration using the Trapezoidal Rule and Simpson's $1/3^{rd}$ Rule.	**15**

Practicals based on Major I: Infinite series and Riemann Integration

Course Code: MAT204D

(15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	P1 to P4: Practicals based on 1.1 to 1.4 **P5 to P8: Practicals based on 2.4 to 2.4** **P9 to P12: Practicals based on 3.1 to 3.4** **P13 to P15: Practicals reserved for revision and extra practice.**	30

Self-Learning topics (Unit wise)

Unit	Topics
3.1	Abel's and Dirichlet's tests for conditional convergence.
3.2	Properties of Beta Gamma functions
3.3	Lengths of plane curves, Areas of surfaces of revolution.
3.4	Approximate integration using the Trapezoidal Rule and Simpson's $1/3^{rd}$ Rule

Online Resources

1. " Calculus of One Real variable" by Prof Joydeep Dutta, IIT Kanpur https://nptel.ac.in/courses/109/104/109104124/ week 5,6,7
2. Numerical Methods by Prof. Ameeya Kumar Nayak, Prof. Sanjeev Kumar by IIT Roorkee https://nptel.ac.in/courses/111/107/111107105/unit8 lecture https://nptel.ac.in/courses/111/106/111106149/week 5,6 lecture 28 to 34

Subject to change if any new relevant course is available.

Reference Books

1. A Basic Course in Real Analysis, Ajit kumar, S. Kumaresan, CRC Press, 2014.
2. Introduction to Real Analysis, John Wilely & Sons, 1994 by.R. G. Bartle-D. R. Sherbert,

3. Calculus and Analytic Geometry, Thomas and Finny ,9th edition, Pearson

4. Calculus T.M. Apostol, Volume I, Wiley & Sons (Asia) Pte, Ltd.

5. Calculus James Stewart, Third Edition, Brooks/ Cole Publishing Company, 1994

Course II:
Title of course: MajorII: Linear Algebra-II **Total credits: 3+1**

Semester – III Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT205B	I	Determinants.	15	45 L	3	75 (60+15)
		II	Linear Transformations.	15			
		III	Dimension and Subspaces.	15			
2	MAT205D		Practicals based on Linear Algebra-I	30	30	1	25
			TOTAL			4	100

Learning Objectives:

1. To introduce the learner to the concepts of
   - Permutation definition of Determinant
   - Eigenvalues and Eigenvectors.
   - Linear Transformations and their Properties.
   - Standard Matrix of a Linear Transformation.
   - Kernel and Range of linear transformation
   - Bases and dimension.
   - Basic spaces associated with a matrix.
   - Rank-Nullity theorem, Rank theorem

2. To study the applications of above concepts to
   - Solving system of equations using Cramer's Rule
   - Finding the Adjugate (classical adjoint or adjunct), Cofactor expansion, finding the Inverse of a matrix using Adjugate.
   - Geometric Meaning of Linear Transformations.
   - Finding the inverse of an invertible matrix
   - Composition of linear transformations

- Inverse of a linear transformation
- Gram-Schmidt Orthonormalization

Learning Outcomes:

1. The learner will be able to apply the concepts of determinants and matrices to solve different problems in linear algebra.

2. The Learner will be able to use properties of Linear Transformations to find kernel and range.

3. The Learner will be able to solve problems on basis and dimension, and find orthonormal basis.

Unit	Content	No. of Lectures
1	**Unit I: Determinants.** 1.1 Permutation definition of Determinant and Properties of the determinants. 1.2 Cramer's Rule, Adjugate (classical adjoint or adjunct), Cofactor expansion, Inverse of a matrix using adjoint. 1.3 Applications of the Determinants. 1.4 Eigenvalues and Eigenvectors.	**15**
2	**Unit II: Linear Transformations**. 2.1 Linear Transformation, Special Linear Transformations, Properties of Linear Transformation, Standard Matrix of a Linear Transformation. 2.2 Geometric Meaning of Linear Transformations. 2.3 Kernel and Range of linear transformation. Properties. 2.4 Composition of linear transformations, Inverse of a linear transformation.	**15**
3	**Unit III: Dimension and Subspaces.** 3.1 Bases and dimension. 3.2 Basic spaces associated with a matrix. 3.3 Rank-Nullity theorem, Rank theorem. 3.4 Gram-Schmidt Orthonormalization.	**15**

Practicals based on Major I: Infinite series and Riemann Integration
Course Code:MAT205D

(15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	P1 to P4: Practicals based on 1.1 to 1.4 **P5 to P8: Practicals based on 2.4 to 2.4** **P9 to P12: Practicals based on 3.1 to 3.4** **P13 to P15: Practicals reserved for revision and extra practice.**	30

Self-Learning topics (Unit wise)

Unit	Topics
1	1.2 Cramer's Rule, Adjugate (classical adjoint or adjunct), Cofactor expansion, Inverse of a matrix using adjoint. 1.3 Applications of the Determinants.
2.	2.1 Standard Matrix of a Linear Transformation. 2.4 Composition of linear transformations, Inverse of a linear transformation.
3.	3.2 Basic spaces associated with a matrix.

Online Resources

1. **Online book on "Linear Algebra with Sage" with Sang-Gu Lee and others.**
2. Online Reference (For Practical) https://ajitmathsoft.wordpress.com/sagemath/
3. **Basic Linear Algebra By Prof. I. K. Rana, IIT Bombay available on NPTEL portal at https://onlinecourses.nptel.ac.in/noc20_ma08/preview**
4. **Linear Algebra Co-ordinated by IIT Kanpur, available on NPTEL portal at https://nptel.ac.in/courses/111/104/111104137/**

Subject to change if any new relevant course is available.

Reference Books:

1. Big-Book-LinearAlgebra-Eng-2015, by Kyobobook (ISBN-978-89-24-03105-8)
2. A First Course in Linear Algebra, by Robert A. Beezer, Version 3.50 (Created: 2015-12-30T15:06:58-08:00; Technical Refresh: 2017-04-14)
3. Elementary Linear Algebra, by Howard Anton, WileyPlus, 11th Edition 2019 (ISBN-978-1-119-62569-8)
4. Linear Algebra: A Geometric Approach by S. Kumaresan, Prentice Hall of India, 2000.
5. Linear Algebra and its Applications, by Gilbert Strang, Thomson Learning Inc., 1988.

N.B.: The use of CAS SageMath to solve problems will be demonstrated and encouraged during Practicals in addition to the traditional problem-solving methods.

Semester – IV Units – Topics – Teaching Hours
Skill Enhancement Course

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT202C	I	Portfolio Management.	15	30 L	2	50
		II	Option Pricing	15			
2	MAT208D		Practical Sessions Based on SEC: Mathematical and Software Skills for Finance II	30	30	1	25
			TOTAL			3	75

Learning Objectives:

1. This course is designed to introduce learners to the mathematical approaches used for design and analysis of financial portfolios.
2. In a practical component of this course, learners will be introduced to time series data visualization and techniques in descriptive statistics using Python.

Learning Outcomes :

1. After completing this course, learners will be able to understand the mathematical approaches used to design and analyse financial portfolios,
2. After completing this course, learners will master the visualization of time series data and apply descriptive statistics techniques using Python.
3. After completing this course, learners will be able to design a minimum variance portfolio and compute the alpha and beta of a portfolio.
4. After completing this course, learners will be able to calculate option prices

Evaluation Pattern:

The course will be assessed for a total of 75 marks and will consist of:

- **Summative Assessment** (End Semester Theory Exam): **50 marks**.

  Paper Pattern:

Q1: **Unit 1**: (20 marks)

Attempt any four out of five (5 marks each)

Q2: **Unit 2**: (20 marks)

Attempt any four out of five (5 marks each)

Q3 **Both Units**: (10 marks)

Attempt any five out of six (2 marks each)

- **Formative Assessment: 25 marks.**

Practical Exam – 50 marks to be converted into 25.

Course Code: MAT202C

Title of course: Mathematical and Software Skills for Finance II

Unit	Content	No. of Lectures
1	**1. Portfolio Management.** 1.1 Investment in two securities, Risk and expected return on a portfolio. 1.2 Investment in several securities, Risk and Expected returns on several securities with matrix algebra. 1.3 Designing minimum variance portfolio. 1.4 Designing minimum variance portfolio with given expected return, minimum variance line. 1.5 Efficient Frontier, alpha and beta factors of a portfolio.	**15**
2	**2. Option Pricing** 2.1 Introduction to European and American Call and Put options. 2.2 Bounds on option prices, Put-Call parity (Statements without proofs). 2.3 Time value of options. 2.4 Pricing European options in binomial tree model. 2.5 Pricing American options in binomial tree model.	**15**

3	**3. Practicals (15 practical sessions each of two lectures)** 1. Working with NumPy. 2. Pandas in Python. 3. Working with Matplotlib in Python. 4. Data description and calculating summary statistics in Python. 5. Time series data visualization in Python. 6. Portfolio theory using matrix algebra. 7. Selecting optimal portfolio weights. 8. The mean-variance efficient frontier in Excel. 9. Calculation of α and β of a portfolio. 10. Demonstration of Capital Asset Pricing Model in Python. 11. Option pricing using Black-Scholes formula in Python. 12. Demonstration: Mock trading. **3 Practical sessions are reserved for revision and extra practice.**	**30**

MAT208D

Practical Sessions Based on SEC: Mathematical and Software Skills for Finance II (15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	Practicals (15 practical sessions each of two lectures) 1. Working with NumPy. 2. Pandas in Python. 3. Working with Matplotlib in Python. 4. Data description and calculating summary statistics in Python. 5. Time series data visualization in Python. 6. Portfolio theory using matrix algebra. 7. Selecting optimal portfolio weights. 8. The mean-variance efficient frontier in Excel. 9. Calculation of α and β of a portfolio. 10. Demonstration of Capital Asset Pricing Model in Python. 11. Option pricing using Black-Scholes formula in Python. 12. Demonstration: Mock trading. **3 Practical sessions are reserved for revision and extra practice.**	30

Online Resources

*Subject to change if any new relevant course is available.

NPTEL :: Mathematics - NOC:Mathematical Portfolio Theory by Prof. Siddhartha Pratim Chakrabarty, Department of Mathematics IIT Guwahati (Lectures 8)

NPTEL :: Mathematics - NOC:Mathematical Finance by Prof. N. Selvaraju Prof. Siddhartha Chakrabarty,Department of Mathematics IIT Guwahati (Lecture 14 and 15)

Reference Books:

1. An Elementary Introduction to Mathematical Finance, Third Edition by Sheldon M. Ross, Cambridge University Press.
2. The Calculus of Finance by Amber Habib, University Press.
3. Mathematics for Finance: An Introduction to Financial Engineering by Amrek Capinski and Tomasz Zastawniak, Springer.
4. Introductory Econometrics for Finance, 4th edition, by Chris Brooks, Cambridge University Press.
5. Python Guide to Accompany Introductory Econometrics for Finance, 4th edition, by Chris Brooks, Kindle book.

Part 4

Title of the course: Minor: Linear Algebra-II

Total credits: 3+1

Semester – III Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	MAT206B	I	Determinants.	15	45 L	3	75 (60+15)
		II	Linear Transformations	15			
		III	Dimension and Subspaces.	15			
2	MAT206D		Practicals based on Linear Algebra-II	30	30	1	25
			TOTAL			4	100

Learning Objectives:

3. To introduce the learner to the concepts of

- Permutation definition of Determinant
- Eigenvalues and Eigenvectors.
- Linear Transformations and their Properties.

- Standard Matrix of a Linear Transformation.
- Kernel and Range of linear transformation
- Bases and dimension.
- Basic spaces associated with a matrix.
- Rank-Nullity theorem, Rank theorem

4. To study the applications of above concepts to
   - Solving system of equations using Cramer's Rule
   - Finding the Adjugate (classical adjoint or adjunct), Cofactor expansion, finding the Inverse of a matrix using Adjugate.
   - Geometric Meaning of Linear Transformations.
   - Finding the inverse of an invertible matrix
   - Composition of linear transformations
   - Inverse of a linear transformation
   - Gram-Schmidt Orthonormalization

Learning Outcomes:

1. The learner will be able to apply the concepts of determinants and matrices to solve different problems in linear algebra.

2. The Learner will be able to use properties of Linear Transformations to find kernel and range.

3. The Learner will be able to solve problems on basis and dimension, and find orthonormal basis.

Title of course: Minor: Linear Algebra-II
Course Code: MAT206B

Unit	Content	No. of Lectures
1	**Unit I: Determinants.** 1.5 Permutation definition of Determinant and Properties of the determinants. 1.6 Cramer's Rule, Adjugate (classical adjoint or adjunct), Cofactor expansion, Inverse of a matrix using adjoint. 1.7 Applications of the Determinants. 1.8 Eigenvalues and Eigenvectors.	
2	**Unit II: Linear Transformations**. 2.5 Linear Transformation, Special Linear Transformations, Properties of Linear Transformation, Standard Matrix of a Linear Transformation. 2.6 Geometric Meaning of Linear Transformations. 2.7 Kernel and Range of linear transformation. Properties. 2.8 Composition of linear transformations, Inverse of a linear transformation.	**15**
3	**Unit III: Dimension and Subspaces.** 3.5 Bases and dimension. 3.6 Basic spaces associated with a matrix. 3.7 Rank-Nullity theorem, Rank theorem. 3.8 Gram-Schmidt Orthonormalization.	**15**

Practicals based on Minor:Linear Algebra-II

Course Code:MAT206D

(15 practical sessions each of 2 lectures)

	Topics	Number of lectures
	P1 to P4: Practicals based on 1.1 to 1.4 **P5 to P8: Practicals based on 2.4 to 2.4** **P9 to P12: Practicals based on 3.1 to 3.4** **P13 to P15: Practicals reserved for revision and extra practice.**	30

Self-Learning topics (Unit wise)

Unit	Topics
1	1.4 Cramer's Rule, Adjugate (classical adjoint or adjunct), Cofactor expansion, Inverse of a matrix using adjoint. 1.5 Applications of the Determinants.
2.	2.1 Standard Matrix of a Linear Transformation. 2.4 Composition of linear transformations, Inverse of a linear transformation.
3.	3.2 Basic spaces associated with a matrix.

Online Resources

1. Online book on "Linear Algebra with Sage" with Sang-Gu Lee and others.

2. Online Reference (For Practical) https://ajitmathsoft.wordpress.com/sagemath/

3. Basic Linear Algebra By Prof. I. K. Rana, IIT Bombay available on NPTEL portal at https://onlinecourses.nptel.ac.in/noc20_ma08/preview

4. Linear Algebra Co-ordinated by IIT Kanpur, available on NPTEL portal at https://nptel.ac.in/courses/111/104/111104137/

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Reference Books:

6. Big-Book-LinearAlgebra-Eng-2015, by Kyobobook (ISBN-978-89-24-03105-8)
7. A First Course in Linear Algebra, by Robert A. Beezer, Version 3.50 (Created: 2015-12-30T15:06:58-08:00; Technical Refresh: 2017-04-14)
8. Elementary Linear Algebra, by Howard Anton, WileyPlus, 11th Edition 2019 (ISBN-978-1-119-62569-8)
9. Linear Algebra: A Geometric Approach by S. Kumaresan, Prentice Hall of India, 2000.
10. Linear Algebra and its Applications, by Gilbert Strang, Thomson Learning Inc., 1988.

N.B.: The use of CAS SageMath to solve problems will be demonstrated and encouraged during Practicals in addition to the traditional problem-solving methods.

Part 6
Syllabus for General Elective -1
Offered by BoS (Mathematics)

Semester III
General Elective -I
Course Title: Logical Reasoning and Quantitative Aptitude III

Course Code: MAT207B
Credits: 3

Course Objectives:

1. To develop familiarity with positive integers, prime numbers, and concepts of divisibility and remainders.
2. To understand patterns of additive (arithmetic) and multiplicative (geometric) nature in sequences and series and to introduce recurrence relations.
3. To introduce the ideas behind important statistical parameters (averages and variations) in an intuitive way.

Course Learning Outcomes:

1. The learner will be able to solve problems based on divisibility rules, find GCD, LCM of two numbers, find remainders, and apply concept of remainders to solve calendar problems.
2. The learner will be able to identify patterns of arithmetic and geometric sequences and use this knowledge to find nth terms, sum up to n terms and sum up to infinity for geometric or telescopic series. The learner will be able to recognize recursive patterns in certain sequences and use simple methods such as backtracking to find nth term of sequences.
3. The learner will be able to calculate and display graphically, the measures of center, measures of location and also calculate various measures of spread of data.

Evaluation Pattern:
The course will be assessed for a total of 75 marks and will consist of:

- **Summative Assessment** (End Semester Theory Exam): **50 marks**.
  Paper Pattern:

Q1: **Unit 1**: (10 marks)

Attempt any two out of three (5 marks each)

Q2: **Unit 2**: (10 marks)

Attempt any two out of three (5 marks each)

Q3: **Unit 3**: (10 marks)

Attempt any two out of three (5 marks each)

Q4 **All Units**: (20 marks)

Attempt any ten out of twelve (2 marks each)

- **Formative Assessment: 25 marks.**
  (Self-Learning Evaluation – 20 marks (Can be in the form of a MCQ test or class assignment or a home assignment) and Class performance – 5 marks)

Unit	Content	No. of Lectures
1	**Number Systems** 1.1 Integers, divisibility and primes, division algorithm, prime factorization, GCD and LCM of two/three numbers, 1.2 Properties of divisibility, number of divisors and sum of divisors of a positive integer, tests of divisibility (divisibility by 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 16), finding remainders and last two digits of an expression (expression includes products and powers). 1.3 Introduction to congruence modulo 'm', basic properties of congruences, application to calendar problems. (leap years, find the day of the week)	15
2	**Progressions and Series** 1.1 Arithmetic and Geometric progressions: n^{th} term formula, sum up to n terms formula, finding three, four or five numbers in A.P and G.P. with given conditions. 1.2 Special series: summing up to n terms of special sequences, formulas for sum of squares and cubes of first n natural numbers, geometric series, and telescopic series. 1.3 Introduction to recurrence relations, formulating a recurrence relation from a given progression and vice versa, formulating recurrence relation for a given problem and solution for simple cases using backtracking.	15
3	**Statistical Reasoning** 3.1 Need of Averages: Arithmetic mean, Weighted arithmetic mean, mode, locating mode graphically. 3.2 Positional Averages: Median, quartiles, deciles and percentiles, locating positional averages graphically. 3.3 Variations, concepts of absolute and relative variations, root-mean-square, standard deviation, variance and consistency.	15

Reference Books

1. Discrete Mathematics and Its Applications by Kenneth H. Rosen, McGraw Hill, Special Indian Edition.
2. Statistics 4th Edition, by David Freedman, Robert Pisani, Roger Purves, Viva-Norton Student Edition.
3. Elements of Discrete Mathematics, 3rd Edition, by C Liu, Tata McGraw Hill
4. Higher Algebra by Hall and Knight, Classic Text Series, 7th edition, Arihant Publication

5. First Steps in Number Theory: A Primer on Divisibility, by Shailesh Shirali, Universities Press, January 2000 edition.
6. Foundations of Discrete Mathematics, by K.D. Joshi, New Age International Publishers limited, 2003 edition.

Part7

Semester IV
General Elective -I
Course Title: Logical Reasoning and Quantitative Aptitude IV

Course Code: MAT208B

Course Objectives:

1. To familiarize with factorial notation, understand the concepts of permutations and combinations using fundamental principles of counting, and study permutations and combinations in various scenarios.
2. To distinguish between simple and compound interest, study the effect of compounding for varying interest rates and time periods, and to understand time value of money.
3. To understand the concept of network diagrams (or directed graphs), their equivalent matrix representations, and to learn shortest path algorithms. To understand patterns and rules for coding and decoding of messages and to learn binary codes.

Course Learning Outcomes:

1. The learner will be able to comprehend various counting problems and use appropriate concepts of permutations and combinations to solve the problems.
2. The learner will be able to solve problems involving investments, profit and loss, simple as well as compound interest and calculate present value and future value.
3. The Learner will be able to apply the concepts of networks or graphs to solve practical problems of ranking teams, finding minimum cost and distance in various network flow diagrams. The Learner will also be able to encode and decode messages using a given cipher. In particular, they will also use binary codes to convert a given word or message to binary form.

Evaluation Pattern:
The course will be assessed for a total of 75 marks and will consist of:

- **Summative Assessment** (End Semester Theory Exam): **50 marks**.
  Paper Pattern:

Q1: **Unit 1**: (10 marks)
Attempt any two out of three (5 marks each)
Q2: **Unit 2**: (10 marks)
Attempt any two out of three (5 marks each)

Q3: **Unit 3**: (10 marks)

Attempt any two out of three (5 marks each)

Q4 **All Units**: (20 marks)

Attempt any ten out of twelve (2 marks each)

- **Formative Assessment: 25 marks.**
  (Self-Learning Evaluation – 20 marks (Can be in the form of a MCQ test or class assignment or a home assignment) and Class performance – 5 marks)

Unit	Content	No. of Lectures
1	1. Counting Techniques 1.1 Factorial notation, Permutations with and without repetition, circular permutations. 1.2 Combinations, Combinatorial identities. 1.3 Permutations and combinations of multisets.	15
2	2. Managing Money 2.1 Profit, loss and partnerships. 2.2 Simple Interest, Compound Interest, Frequency of compounding and effective interest rates, Comparing accumulated values of simple interest Vs Compound interest with various frequencies (Conceptual understanding of linear growth Vs exponential growth) 2.3 Time value of money	15
	3 Network Diagrams and Codes 3.1 Ranking problems: Concept of directed graph, Matrix representation of directed graph (Dominance matrix), Using dominance matrix to rank players. 3.2 Network flow diagrams, shortest path between two nodes, minimum cost, minimum distance problems. 3.3 Coding and Decoding, Binary logic, Concept of binary addition	15

Reference Books

1. Introductory Combinatorics, 5th Edition, by Brualdi, Pearson
2. Learning Mathematics through Modelling and Simulation by Jonaki Ghosh, Amber Habib and Geetha Venkatraman, University Press
3. Elements of Discrete Mathematics, 3rd Edition, by C Liu, Tata McGraw Hill

4. An Elementary Introduction to Mathematical Finance, Third Edition by Sheldon M. Ross, Cambridge University Press.
5. Introduction to Graph Theory by Douglas B. West, Pearson Education Asia.
6. Higher Algebra by Hall and Knight, Classic Text Series, 7th edition, Arihant Publication
7. Discrete Mathematics, B.S. Vatsa, Suchi Vatsa, New Age International Publishers limited, 4th edition.
8. Foundations of Discrete Mathematics, by K.D. Joshi, New Age International Publishers limited, 2003 edition.
9. Using and Understanding Mathematics: A quantitative Reasoning Approach: 7th edition – Bennett and Briggs (Pearson)