P. D. E. A's

Prof. Ramkrishna More Arts, Commerce and Science College, Akurdi, Pune-411044

Affiliated to

Savitribai Phule Pune University

Choice based Credit System

Under Autonomy and NEP-2020

Implemented from Academic Year 2023-24

Rules and Regulations

1. **National Credit Framework (NCrF):** For creditisation and integration of all higher education qualifications leading to a certificate/ diploma/ degree with multiple entry and exit options, college will refer to National Credit Framework (NCrF) which encompasses the qualification frameworks for higher education, vocational and skill education and school education, namely National Higher Education Qualification Framework (NHEQF), National Skills Qualification Framework (NSQF) and National School Education Qualification Framework (NSEQF) respectively.
2. **Structure of Four years multidisciplinary UG Programme and Five Years Integrated Multidisciplinary Master's Degree Programmes with Multiple Entry and Exit Options at Different Levels:**

   (i) Students will have the flexibility to enter four years multidisciplinary Under Graduate Programme in odd semesters and exit a programme after the successful completion of even semesters as per their future career needs.

   (ii) Students will get a Certificate after a One year programme (minimum 40 Credits), a Diploma after two years (minimum 80 Credits), a Bachelor's degree after three years (minimum 120 Credits), and a Bachelor's degree with Research or Honours after Four years (minimum 160 Credits).
3. **Qualification Type and Credit Requirements of Four Years Multidisciplinary Degree Programme with Multiple Entry and Exit Options**

   (i) Details of qualifications, minimum credit requirements, exit credit courses, year and semester are as under:

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	UG Certificate	40	44	2	1
5.0	UG Diploma	80	88	4	2
5.5	Three Years Bachelor's degree	120	132	6	3
6.0	Bachelor's degree Honour's with Major	160	176	8	4
	Bachelor's degree Honour's with Major	160	176	8	4
7.0	Master's Degree	200	220	10	5
8.0	Ph. D.	----	-----	-----	----

   (ii) An exit 6-credit bridge course(s) lasting two months, including at least 6-credit job specific internship/apprenticeship that will help the graduates acquire job-ready competencies required to enter the workforce will be an additional requirement for the award of the undergraduate Certificate/ Diploma/ three year Bachelor's Degree.

   (iii) On exit, the students will have the option to re-enter the programme in the college, or in a different higher education institution. Re-entry at various levels for lateral entrants in academic programmes should be based on the earned and valid credits as deposited and accumulated in the Academic Bank of Credits (ABC) through Registered Higher Education Institutions (RHEI) and proficiency test records.

   (iv) Eligibility for admission to the fourth year of four-year **Honours with Research Degree Programmes** as per UGC guidelines: Minimum CGPA of 7.5 or minimum 75% at three-year degree.

   (v) PG curriculum, as illustrated below, have flexibility a) One-year Post-Graduate Diploma (PGD), b) Two year Post-graduate Programme and c) 5 Years Master's

degree programmes with multiple Entry and Exit options at different levels.

(a) Post-Graduate Diploma (PGD): Programme duration- One year (2 semesters) after any bachelor's degree, min. 40 credits

(i) UGC: 1-Year (2 semesters) Post-Graduate Diploma (PGD) after 3-years Bachelor's degree: Level 6.0

(ii) UGC: 1-Year (2 semesters) PGD after 4 years Bachelor's degree (Honors/ Research): Level 6.5

(b) Master's Degree:

(i) UGC: 2-Years (four semesters) Master's Degree after obtaining a 3-years Bachelor's degree, Minimum 40 credits/year, second year devoted entirely to research, PG – 2nd year: Level 6.5

OR

(i) 1-Year (two semesters) Master's Degree after obtaining a 4-year Bachelor's degree (Honours/Research): Minimum 40 credits: Level 6.5

(c) Level 8 represents Ph. D. Research Degree.

(d) A 5-year Integrated Bachelor's and Master's programme shall have a minimum of 220 credits.

(e) Master's and doctoral programmes, while providing rigorous research-based specialization, should also provide opportunities for multidisciplinary work, in academia, government, research institutions, and industry.

4. Lateral Entry/ Re-entry at higher Levels after exit from lower levels of four years multidisciplinary UG degree programme:

(i) The credit points earned and accumulated shall be used to determine the eligibility for taking admission to various programs at multiple levels, subject to fulfilment of the broad principles laid down under NCrF. Students who leave with a Certification, Diploma, or a Basic Bachelor's Degree will be eligible to re-enter the programme at the exit level to complete or progress to the next level through lateral entry mode. Depending upon the academic and physical facilities available, the State Universities/ Autonomous Colleges (Higher Education Institutions or HEI) may earmark specific seats/ intake for lateral entry into the second year/ third year/ fourth year of a four years multidisciplinary UG degree programme as approved by Professional Standard Setting Bodies (PSSB/Govt. of Maharashtra/ statutory council of affiliating University plus any consequential vacancies caused by exits to an ongoing programme (four-year Degree Programme and Integrated Master's or second year Master's). Lateral entry or Re-entry is open to those students if he/she has either –

(a) successfully completed the first year/second year/third year of the particular four years multidisciplinary degree programme in any ABC registered HEI with valid credits in ABC and re-entering into the second year/third year/fourth year, respectively of the same four years degree programme of any ABC registered HEI, within stipulated/ permissible period of years as decided by Statutory Councils of that HEI

OR

(b) Already successfully completed a multidisciplinary four-year first-degree programme and is desirous of and academically capable of pursuing another multidisciplinary four years first-degree programme in an allied subject.

(ii) A student will be allowed to enter/re-enter only at the odd semester. Re-entry at various levels for lateral entrants in academic programmes should be based on the earned and valid credits as deposited and accumulated in Academic Bank of Credits (ABC) through Registered Higher Education Institutions (RHEI) and proficiency test records. However, in terms of the admission eligibility requirements, the student shall belong to the same faculty/ discipline in terms of Major Subject i.e., the Major subject of his earlier Programme and the Major subject of the new Programme for

which he is seeking admission must be from the same faculty/discipline. Reservation for lateral entry will be executed as per the Government of Maharashtra norms.

5. Distribution of Credits across Multidisciplinary Four Years Degree Programme:

(i) Four-year multidisciplinary degree programme with Honours/ Specialization Degree will have Internship and Core /Major Courses with a minimum of 22 credits per sem. in the Fourth Year.

(ii) Four-year multidisciplinary degree programme with Research will have Research Projects, Seminars, Dissertations and Internships with a minimum of 22 credits per Sem. in the Fourth Year.

(iii) Students shall select a 'Major or Core Subject/ Discipline' and a '**Minor Subject/Discipline' from the lists of various Subject Combinations and Options provided the Colleges.** In general, for the four years multidisciplinary bachelor's degree programme, the distribution of credits will be as follows:

(a) Disciplinary/interdisciplinary Major/ Core Subject (minimum of 68 credits)- Mandatory and Elective Courses

(b) Disciplinary/interdisciplinary Minor Subject (maximum of 22 credits)

(c) Skill based/Vocational studies corresponding to the Major/ Core Subject (8 credits)

(d) Field projects/internship/apprenticeship/community engagement and service corresponding to the Major/ Core Subject (14-22 credits) with a maximum of six credits per Semester

(e) Generic/ Open Electives through Baskets of Elective Courses (12 credits),

(f) Ability Enhancement Courses including Languages, Literature and Environmental Studies (12 credits),

(g) In-built modules on the Indian Knowledge System (IKS) in Major/ Core Subject at Level 4.5 – 2 credits

(h) Value-based Education, Life Skills and Professional Ethics: Co-curricular Courses such as Sports and Culture, NSS/NCC and Fine/ Applied/Visual Arts (8 credits).

Student can earn some credits (SEC/VSC/GE/OE) in the form of online from-

(i) The National Skills Qualifications Framework (NSQF) organizes qualifications for Vocational and Skill Courses in a series of 8 levels based on professional knowledge, professional skills, core skills and responsibilities, in the increasing order of complexity and competency.

(ii) University Grants Commission (Credit Framework For Online Learning Courses through Study Webs of Active-Learning for Young Aspiring Minds) Regulations, 2021, **permits up to 40 per cent of the total courses being offered in a particular programme in a semester through the Online Learning Courses offered through the Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM) platform**.

6. Examination and Assessment Process:

(i) The basic principle of the credit framework is that credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

(ii) Exit options are provided with certification, diploma and basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a four years multidisciplinary degree programme. Students will receive a Bachelor's degree with Honours/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries.

(iii) For the smooth success of four-year multidisciplinary degree programme with multiple entry and exit systems, the examination mode will be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of students

learning at the end of an instructional unit) examination modes. This is in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019)'.

(iv) Evaluation of each students in each course will be done as follows

a. Each theory or practical course will be of 2 credits = 50 mark

b. Internal evaluation 30% weightage (15 mark)

c. External evaluation 70% weightage (35 marks)

d. Students should secure 40% marks in each type of evaluation for successful completion of a course (student should secure at least 6 marks in internal and 14 marks in external evaluation).

(v) Evaluation Pattern.

a. Internal evaluation - Two written test, each of 20 marks will be conducted i. e. two tests on two modules. 1st assignment after completing 6 weeks of teaching and 2nd on completion of 13th week of teaching. Question paper should be designed so that evaluation of CO, PO, PSO can be performed. 10 marks out of 15 will be assigned from these written tests. Remaining 5 marks will be assigned from other types of evaluation such as seminars, orals, poster presentation, open book challenging tests, surprise test, objective test on whole syllabus of the course (at least 40 questions of objective type must be designed), etc. for 5 marks at least two different types technique must be utilized.

b. External Evaluation - External evaluation will be done at the end of semester. For theory, 35 marks written examination will be conducted and time of examination will be 2-hours.

7. Declaration of Results:

(i) Declaration of result is based on the Semester Grade Point Average (SGPA) earned towards the end of each semester or the Cumulative Grade Point Average (CGPA) earned at the completion of all eight semesters of the programme and the corresponding overall alpha-sign or letter grades as given in Table 2. If some candidates exit at the completion of the first, second or third year of the four years Undergraduate Programmes, with Certificate, Diploma or Basic Degree, respectively, then the results of successful candidates at the end of the second, fourth or sixth semesters shall also be classified on the basis of the CGPA obtained in the two, four, six or eight semesters, respectively. Successful candidates at the end of the tenth semester of the integrated Master's Degree Programmes shall also be classified on the basis of CGPA obtained in the ten semesters of the Programmes. Likewise, the successful candidates of one year or two semesters Master's Degree Programme are also classified on the basis of the CGPA of two semesters of the Master's Degree Programme.

Table-2: Grades on degree certificate/mark sheet will be assigned to the students as per the following table

Semester GPA/ Program CGPA Semester/Program	**% of Marks**	**Alpha-Sign / Letter Grade Result**
9.00-10.00	90-100	O (outstanding)
8.00 - <9.00	80.00 – <90.00	A+ (Excellent)
7.00 - <8.00	70.00-<80.00	A (Very Good)
6.00 - <7.00	60.00-<70.00	B+ (Good)

5.50 - <6.00	55.00-<60.00	B (Above Average)
5.00 - <5.50	50.00-<55.00	C (Average)
4.00 - <5.00	40.00-<50.00	P (Pass)
Below 4.00	< 40	F (Fail)
Ab	----------	Absent

(ii) A student obtaining Grade F shall be considered failed and will be required to reappear in the examination. For non-credit courses 'Satisfactory' or "Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

8. Award of Major and Minor Degree:

(i) A student pursuing four-year multidisciplinary UG programme will be awarded an appropriate Honours/ Research degree in Major/ Core Subject on completion of VIII Semester with the minimum of 176 credits if he secures in that Subject at least 50% of the total credits for that programme. He shall thus study the specific number of Mandatory Core Courses, Core Electives, Vocational and Skill Courses and Field projects/ Internships connected to Core Subjects in eight semesters so as to cover at least 50% of the total credits.

(ii) In case of Research Degree, a student shall pursue research project and write dissertation in that Major in the VII and VIII semesters.

On the basis of above rules and regulations under NEP-2020 following course frame work is adopted by the Prof. Ramkrishna More Arts, Commerce and Science College, Akurdi, Pune-411044 for the completing of four years honours degree in Major and Minor subjects.

9. Distribution of Credits across Four Years Degree Programmes:

In general, for the four years' bachelor's degree programme, the distribution of credits will be as follows:

(a) Major (Core) Subject comprising Mandatory and Elective Courses:

i. Minimum 50% of total credits corresponding to Three/Four - year UG Degree-Mandatory Courses offered in all Four years;

ii. 2 credit course on Major Specific IKS shall be included under Major;

iii. Elective courses of Major will be offered in the third and/or final year.

iv. Vocational Skill Courses, Internship/ Apprenticeship, Field Projects, Research Projects connected to Major first to fourth year.

(b) Minor Subject: 18-20 Credits

i. The Minor subjects may be from the different disciplines of the same faculty of DSC Major (Core) or they can be from different faculty altogether.

ii. The credits of Minor subjects shall be completed in the first three years of UG Programme.

(c) Generic/ Open Elective Courses (OE): 10-12 credits

i. It is to be offered in I and/or II year

ii. Faculty-wise baskets of OE shall be prepared by University/ Autonomous Colleges.

iii. OE is to be chosen compulsorily from faculty other than that of the Major.

(d) Vocational and Skill Enhancement Courses (VSEC): 14-16 credits

Vocational Skill Courses (VSC): 8-10 credits, including Hands on Training corresponding to the Major and/or Minor Subject:

i. To be offered in first to three years;

ii. Wherever applicable vocational courses will include skills based on advanced laboratory practicals of Major

 # Skill Enhancement Courses (SEC): 06 credits

i. To be offered in I and II year;

ii. To be selected from the basket of Skill Courses approved by University/ Autonomous Colleges

(e) Ability Enhancement Courses (AEC), Indian Knowledge System (IKS) and Value Education Courses (VEC): 14 Credits

- **AEC: 08 credits**

i. To be offered in I and II year

ii. English: 04 Credits

iii. Modern Indian Language: 04 credits

iv. To be offered from the Basket approved by the College;

The focus for both languages should be on linguistic and communication skills.

o IKS: 2 Credits

i. To be offered in I Year

ii. Courses on IKS to be selected from the basket of IKS courses approved by the Colleges

o VEC: 04 Credits

i. To be offered in I year

ii. Value Education Courses (VEC) Environmental Science Education (Compulsory), Understanding India, and Digital and Technological Solutions.

(f) Field Projects/ Internship/ Apprenticeship/ Community Engagement and Service corresponding to the Major (Core) Subject, Co-curricular Courses (CC) and Research Project

o Internship/Apprenticeship corresponding to the Major (Core) Subject: 8 Credits

o Field Projects/Community Engagement and Service corresponding to the Major (Core) Subject: minimum 4-6 credits

To be offered in II, and III years of UG Degree Programmes.

o Co-curricular Courses (CC) such as Health and Wellness, Yoga education sports, and fitness, Cultural Activities, NSS/NCC and Fine/ Applied/ Visual/ Performing Arts: 8 credits. To be offered in I and/or II year

o Research Projects: 12 credits

To be offered in the final year for 4-year Honours with Research UG Degree

The UGC Regulations, 2021 permit up to 40% of the total courses being offered in a particular programme in a semester through the Online Learning Courses offered through the SWAYAM platform and/or other State Level Common Platforms which can be developed in due course with the participation of different Universities/ HEIs.

Abbreviations: Generic/ Open Electives: **GE**/**OE**; Vocational Skill and Skill Enhancement Courses: **VSEC**; Vocational Skill Courses: **VSC**; Skill Enhancement Courses**: SEC**; Ability Enhancement Courses: **AEC**; Indian Knowledge System: **IKS**; Value Education Courses: **VEC; OJT**: On Job Training: Internship/ Apprenticeship; Field projects: **FP**; Community engagement and service: **CEP**; Co-curricular Courses: **CC**; Research Methodology-**RM**; Research Project: **RP** Note: The Credit Distribution Table given above is illustrative only. The Universities/ Autonomous Colleges may suitably modify within the broader framework of credit distribution across six verticals.

Graduate and Honors Degree Course Framework under Autonomy as per NEP-2020

If not mentioned, each proposed course (theory/practical) is of 2 credits

Sem.	Major Courses	Major Elective Curses	Minor Curses	VSC	IKS	FP/OJT/ CEP	GE/OE	SEC	AEC	VEC	CC	Total Credits
First Year Certificate Course												

I	2 theory + 1 Practical	0	0	1 Theory	1 Theory	0	1 theory + 1 Practical	1 theory/ practical	1 theory	1 theory	2 Credit	22
II	2 theory + 1 Practical	0	1 Theory	1 Practical	0	0	1 theory + 1 Practical	1 theory/ practical	1 theory	1 theory	2 Credit	22
Second Year Graduate Diploma												
III	3 theory + 1 Practical	0	1 Theory + 1 Practical	1 Theory	0	FP (2 Credit)	1 theory	0	1 theory		2 Credit	22
IV	3 theory + 1 Practical	0	1 Theory + 1 Practical	0	0	CEP (2 Credit)	1 Practical	1 theory/ practical	1 theory		2 Credit	22
Third Year Graduate Degree												
V	3 theory + 2 Practical	1 Theory + 1 Practical	1 Theory + 1 Practical	1 Practical	0	FP/CEP (2 Credit)	0	0	0	0	0	22
VI	3 theory + 2 Practical	1 Theory + 1 Practical	1 Theory + 1 Practical	0	0	OJT (4 Credit)	0	0	0	0	0	22
VII and VIII Semester honours degree with major												
VII	5 theory + 2 Practical	1 Theory + 1 Practical	RM 4 Credits	0	0	0		0	0	0	0	22
VIII	5 theory + 2 Practical	1 Theory + 1 Practical	0	0	0	OJT (4 Credit)	0	0	0	0	0	22
VII and VIII Semester honours degree with research												
VII	4 theory + 1 Practical	1 Theory + 1 Practical	RM 4 Credits	0	0	RP (4 Credit)	0	0	0	0	0	22
VIII	4 theory + 1 Practical	1 Theory + 1 Practical	0	0	0	RP (8 Credit)	0	0	0	0	0	22

Post Graduate Degree Course Framework under Autonomy as per NEP-2020

If not mentioned, each proposed course (theory/practical) is of 2 credits

Sem.	Major Courses	Major Elective Curses	Minor Curses	VSC	IKS	FP/OJT/CEP	GE/OE	SEC	AEC	VEC	CC	Total Credits
PG-I												
VII	5 theory + 2 Practical	1 Theory + 1 Practical	RM 4 Credits	0	0	0		0	0	0	0	22
VIII	5 theory + 2 Practical	1 Theory + 1 Practical	0	0	0	OJT (4 Credit)	0	0	0	0	0	22
PG-II												
IX	5 theory + 2 Practical	1 Theory + 1 Practical	0	0	0	Research Project (4 credits)		0	0	0	0	22
X	5 theory + 2 Practical	1 Theory + 1 Practical	0	0	0	OJT (4 Credit)	0	0	0	0	0	22

Definitions:

1. **One semester** = 15 weeks
2. **1-credit theory** = 15 hours i.e. for 1 credit, 1 hour per week teaching is to be performed.

   15 hours of 1-credit are splinted as 12 hours actual teaching + 3 hours Tutorial (practice problem solving sessions, repeated discussion on difficult topics, discussion on student's difficulties, questions discussion and internal evaluation)
3. **1-credit practical** = 30 hours. Thus, 1 credit practical = 2 contact hours in laboratory per week. 30 hours splinted as 24 hours actual table work and 6 hours for journal competition, oral on each practical and other internal evaluation.
4. **Each theory course of any type** (major, minor, VSC, VEC, OE/GE, VEC, SEC, CC, etc.) **is of 2 credits**.
   a. **Theory per semester:** Contact hours = 24 teaching + 6 tutorials (problem solving sessions, repeated discussion on difficult topics, difficult solution, questions discussion and internal evaluation)

b. Each course will be of two modules, One module = 15 hours

c. Each module may consist of one or more than one chapter.

5. Each practical course of any course is of 2 credits = 60 hours per semester

a. Minimum 12 laboratory sessions will be conducted in one semester.

b. Each laboratory sessions will be of 4 hour.

Structure of the course: M. Sc. Mathematics

Semester	Course Type	Course code	Generic Name	Title of the paper	Credit	No. of Lectures /Practical to be conducted
I	Core	MTMAT-511	Mathematics theory paper-1	Linear Algebra	2	30
		MTMAT-512	Mathematics theory paper-2	Group Theory	2	30
		MTMAT-513	Mathematics theory paper-3	Advanced Calculus	2	30
		MTMAT-514	Mathematics theory paper-4	Ordinary Differential Equations	2	30
		MTMAT-515	Mathematics theory paper-5	Financial Mathematics-I	2	30
		MTMAP-516	Mathematics practical paper-1	Practical on Linear Algebra and Group theory	2	12
		MTMAT-517	Mathematics practical paper-2	Practical on Advanced Calculus and Financial Mathematics-I	2	12
	Elective	MTMAT-518-A	Mathematics theory paper-6-A	Python Programing	2	30
		MTMAT-518-B	Mathematics theory paper-6-B	Dynamical Systems	2	30
		MTMAP-519-A	Mathematics practical paper-3-A	Practical on Python programming	2	30
		MTMAP-519-B	Mathematics practical paper-3-B	Practical on Dynamical Systems	2	30
	RM	MTRMT-520		Research Methodology	4	60
II	Core	MTMAT-521	Mathematics theory paper-7	Number Theory	2	30
		MTMAT-522	Mathematics theory paper-8	Rings Theory	2	30
		MTMAT-523	Mathematics theory paper-9	Measure and Integration	2	30
		MTMAT-524	Mathematics theory paper-10	Partial Differential Equations	2	12
		MTMAT-525	Mathematics theory paper-11	Financial Mathematics-II	2	30
		MTMAP-526	Mathematics practical paper-4	Practical on Number Theory and Ring Theory	2	12
		MTMAP-527	Mathematics practical paper-5	Practical on Measure and Integration and Partial Differential Equation	2	12
	Elective	MTMAET-528-A	Mathematics theory paper-12-A	Integral Equations	2	30
		MTMAET-528-B	Mathematics theory paper-12-B	Cryptography	2	30
		MTMAET-529-A	Mathematics practical paper-6-A	Practical on Financial Mathematics	2	12
		MTMAET-529-B	Mathematics practical paper-6-B	Practical on Cryptography	2	12
	OJT/FP	MTOJT-530			4	60

Semester	Course Type	Course Code	Generic Name	Title of the Paper	Credit	No. of Lectures/Practical to be conducted
III	Core	MTMAT-631	Mathematics theory paper-13	General Topology	2	30
	Core	MTMAT-632	Mathematics theory paper-14	Fourier Series and Boundary Value Problems	2	30
	Core	MTMAT-633	Mathematics theory paper-15	Field theory	2	30
	Core	MTMAT-634	Mathematics theory paper-16	Combinatorics	2	30
		MTMAT-635	Mathematics theory paper-17	Probability and Statistics	2	30
		MTMAP-636	Mathematics Practical paper-7	Practical on Probability and Statistics and Combinatorics	2	12
		MTMAP-637	Mathematics Practical paper-8	Latex	2	12
	Elective	MTMAET-637-A	Mathematics theory paper-17-A	Coding Theory	2	30
		MTMAET-637-B	Mathematics theory paper-17-B	Foundation Of Data Science	2	30
			Mathematics Practical paper-9-A	Practical on Coding Theory	2	12
			Mathematics Practical paper-9-B	Practical on Foundation Of Data Science	2	12
	RP	MTRPT-636		Research Project	4	
IV	Core	MTMAT-641	Mathematics theory paper-18	Functional analysis	2	30
	Core	MTMAT-642	Mathematics theory paper-19	Differential Geometry	2	30
	Core	MTMAT-643	Mathematics theory paper-20	Lattice Theory	2	30
		MTMAT-644	Mathematics theory paper-21	Machine Learning	2	30
		MTMAT-645	Mathematics theory paper-22	Graph Theory	2	30
		MTMAP-646	Mathematics practical paper-10	Practical on Machine Learning	2	12
		MTMAP-647	Mathematics practical paper-11	Practical on Lattice Theory and Graph Theory	2	12
	Elective	MTMAET-648-A	Mathematics theory paper-19	Data Analytics	2	30
		MTMAET-648-B	Mathematics theory paper-20	Fractional Calculus	2	30
		MTMAET-649-A	Mathematics theory paper-19	Practical on Data Analytics	2	12
		MTMAET-649-B	Mathematics theory paper-20	Practical on Fractional Calculus	2	12
	RP	MTRPT-645		Research Project	8	

SEMESTER- I

Major Paper No: 01

Course Code: MTMAT-511 **Course Type - Theory**

Course Name : Linear Algebra **Lectures : 30**

Credits alloted - 2

Module - I

Unit 1: Vector Spaces and Linear Transformation (6 Lectures)

1.1. Vector Spaces

1.2. Subspaces

1.3. Basis

1.4. Dimension

1.5. Linear Transformation

Ref Book – 1 (Page numbers – 95 to 111)

Unit 2: Linear Mappings and Matrices (8 Lectures)

2.1. Linear Mappings

2.2. Quotient Spaces

2.3. Vector space of linear mappings

2.4. Linear mappings and matrices

Ref Book – 1 (Page numbers – 112 to 129)

Module - II

Unit 3: Reduction of matrices to canonical forms (8 Lectures)

3.1 Eigenvalues and Eigenvectors

3.2 Triangularization of a matrix

3.3 Jordan Canonical form

Ref Book – 1 (Page numbers – 140 to 159)

Unit4: Metric Vector spaces (8 Lectures)

4.1 Bilinear forms

4.2 Symmetric bilinear forms

4.3 Quadratic forms

4.4 Hermitian forms

Ref Book – 1 (Page numbers – 160 to 177)

Reference Books:

1. **First Course in Linear Algebra: P B Bhattacharya , S.K. Jain , S.R. Nagpaul (New age international Publishers)**

Unit1: Chapter 4

Unit 2: Chapter 5 (5.1 to 5.4)

Unit 3: Chapter 6

Unit 4: Chapter 7 (7.1 to 7.4)

2. **N.S. Gopalkrishnan: University Algebra (Wiley Eastern Ltd)**

Course Outcomes :

CO-1 :Define Concepts of Vector Space, Subspace, linear dependence, basis, dimension.

CO-2 : Describe the concept of Linear Mappings

CO-3 : Solve examples to find the inverse of linear transformation and Jordan canonical form

CO-4 : Calculate coordinate vector , orthogonality, orthonormality, norm of vectors using formulas

CO-5 : Solve Triangular and Diagonal Matrix using linear transformation

CO-6 : Describe the concept of Bilinear Forms

SEMESTER- I

Major Paper No: 02

Course Code: MTMAT-512 **Course Type : Theory**

Course Name: Group Theory

Credits Allotted : 2 **Lectures allotted: 30**

Module I

Unit 1: Groups, Subgroups and Cyclic Groups [4 Lectures]

2.1 Definition and Examples of Groups; Properties of Groups; Order of a finite group; Order of an element in group; Subgroups; Subgroup Tests.

2.2 Cyclic Groups; Properties of Cyclic Groups; Classification of Subgroups of Cyclic Groups.

Ref Book – 1 (Page numbers – 40 to 83)

Unit 2 : Permutation Groups, Isomorphism [6 Lectures]

1.1 Permutations Groups; Definition and notation; Cycles; Properties of Permutations; Even and odd permutations; Alternating Group of degree n.

1.2 Isomorphism of Group; Properties of Isomorphisms; Cayley's Theorem; Automorphisms.

Ref Book – 1 (Page numbers – 90 to 129)

Module II

Unit 3 : Cosets, Lagrange's Theorem, External Direct Product [6 Lectures]

3.1 Cosets; Lagrange's Theorem and consequences.

3.2 External Direct Products; Properties of External Direct Products; Group of units modulo n as an external direct product.

Ref Book – 1 (Page numbers – 132 to 170)

Unit 4 : Normal Subgroups, Homomorphisms [7 Lectures]

4.1 Normal Subgroups; Factor Groups; Application of Factor Groups; Internal Direct Products.

4.2 Group Homomorphisms; Definition and examples;

Properties of Homomorphisms; First Isomorphism Theorem.

Ref Book – 1 (Page numbers – 171 to 205)

Unit 5 : Fundamental Theorem and Sylow Theorems [7 Lectures]

5.1 Fundamental Theorem of Finite Abelian Groups; Proof of the Fundamental Theorem.

5.2 Conjugacy Classes; Class Equation; The Sylow Theorems; Applications of sylow theorems.

Ref Book – 1 (Page numbers – 209 to 222 & 395 to 411)

Reference Books:

1. **Joseph Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa Publication**

   Unit 1 : Chapter 2,3,4

   Unit 2 : Chapter 5,6

   Unit 3 : Chapter 7,8

   Unit 4 : Chapter 9,10

   Unit 5 : Chapter 11, 24

Course Outcomes

CO-1 : Define Group, Cyclic Group, Order of an element.

CO-2 : Use these definitions to check whether a given group is cyclic or not, and find a generator for a subgroup of a given order.

CO-3 : Define Permutation group, Even and Odd Permutation, Isomorphism of groups.

CO-4 : Find cosets of subsets of a group and define External Direct Product.

CO-5 : Define and find Normal subgroups of a group and Factor groups.

CO-6 : State and prove Fundamental Theorem of Finite abelian Group and find conjugacy classes.

SEMESTER- I

Major Paper No: 3

Course Code: MTMAT-513 **Course Type : Theory**

Course Name: Advanced Calculus

Credits Allotted : 2 **Lectures allotted: 30**

Module - I

UNIT-I: Differential Calculus of Scalar and Vector Fields. [8 lectures]

1. The derivative of a scalar field with respect to a vector; Directional derivatives
2. partial derivatives; Partial derivatives of higher order; Inverse function theorem and Implicit Function theorem . (without proof)
3. Directional derivatives and continuity; The total derivatives; The gradient of a scalar field

Ref Book – 1 (Page numbers – 252 to 261)

(For Inverse function theorem and Implicit Function theorem :

Ref -2(page 372 and 374))

UNIT-II: Line Integrals and Surface integral [7 lectures]

1. Paths and line integrals; Other notations for line integrals; Basic properties of line integrals.
2. The concept of work as a line integral; Line integrals with respect to arc length; Further applications of line integrals.
3. Open connected sets. Independence of the path; The first and second fundamental theorem of calculus for line integral

Ref Book – 1 (Page numbers – 323 to 339)

Module - II

UNIT-II: Line Integrals and Surface integral [7 lectures]

1.Surface integrals; Change of parametric representation
2.The theorem of Stokes;
3.Curl and divergence of a vector field;
4. Properties of curl and divergence;
5. The divergence theorem (Gauss' theorem) and
6. Application of divergence theorem.

Ref Book – 1 (Page numbers – 430 to 447 and 457 to 463)

UNIT-III: Multiple Integrals [08 lectures]

1. Double integrals, Application to area and Volume
2. Green's theorem in the plane; Some Application of Green's Theorem
3. Change of variables in double integral;,Trasformation formula
4. Change of variables in an n-fold integrals.

Ref Book – 1(Page numbers-353 to 401 and 407 to 415)

Reference Books:

1)Tom M. Apostol, Calculus Volume II (Second Edition) Indian Reprint 2016 (JohnWiley & Sons, Inc) ISBN:978-81-265-1520-2. (Unit 1: Chapt 8, Unit 2-chp 10 and chapt12)

2)Mathematical Analysis Second Edition Tom M.Apostol (Addison -Wesley Publishing Company)

Course Outcomes:

CO1: Describe the basic concept of directional derivative and partial derivatives.

CO2: Solve example to find directional derivative, check continuity of function

CO3: Explain the concept of line integral and application of line integral.

CO4: Explain parametric representation of surface integral, solve examples

CO5: State divergence theorem and it's application and examples.

CO6: Solve example of double integrals.

SEMESTER-I

Major Paper No:4

Course Code: MTMAT-514 **Course Type : Theory**

Course Name : Ordinary Differential Equation

Credits Allotted : 2 **Lectures allotted: 30**

Module I

Unit 1: : Linear Differential equations with constant coefficients [5 Hours]

1. Linear Differential Equation with constant coefficients
2. To find complementary function(C.F.) of a given function and its working.
3. Particular Integral
4. General Methods of getting Particular Integral

Ref Book – 2 (Page numbers- chapter 5- sec 2 to sec 3)

Ref Book – 3 (Page numbers- chapter 16- pg no. 99 to 107)

Unit 2: Linear equations with variable coefficients [10 Hours]

1. Second order homogeneous equations
2. Initial value problems for second order homogeneous equation
3. Linear Dependence and Independence
4. Wronskian and Linear Independence
5. Reduction of order of homogeneous equation
6. Homogeneous equation with analytic coefficient

Ref Book – 1 (Page numbers- 49 to 65 & 103 to 121 & 126 to 129)

Module II

Unit 3: Linear Equations with regular singular points [8 Hours]

1. Euler equation
2. Second order equation with regular singular points
3. Bessel's equation

Ref Book – 1 (Page numbers- 143 to 159 & 162 to179)

Unit4: Existence and uniqueness of solutions to first order equation [7 Hours]

1. Equations with variables separated
2. Exact equations
3. Lipschitz condition

4. Approximation to and uniqueness of solutions

Ref Book – 1 (Page numbers- 185 to 199 & 208 to 209& 222 to 226)

Reference Books:

1. **E. A. Coddington,** An Introduction to Ordinary Differential Equations (Prentice- Hall).
2. **William F. Trench,** Elementary Differential Equation with Boundary Value Problem,
3. **Frank Ayres JR**, Theory and problem on Differential Equations , **Schaum's Outline series,**
4. **G. F. Simmons and S. G. Krantz, Differential Equations (Tata McGraw-Hill).**

Course Outcomes:

CO-1. Define differential equation, ordinary differential equation, degree, order of DE

CO-2. Second order & n th order DE with variable coefficient, reduction of order method

CO-3. Can find Legendre polynomials, can identify & solve Bessel's equation, legendre equation.

CO-4. Can identify & find solution to Euler's Equation, can identify regular singular, ordinary, singular point, indicial equation

CO-5. Solve DE by variable separable method, can solve exact DE By finding integrating factor.

CO-6. Lipschitz condition & constant

SEMESTER-I

Major Paper No: 05

Course Code: MTMAT-515 **Course Type : Theory**

Course Name: Financial Mathematics - I **Lectures: 30**

Credits Allotted : 2

Module - I

Chapter 1 :: Basic Concepts **[6 Hours]**

1. Arbitrage
2. Return and Interest
3. The Time Value Of Money
4. Bonds , Shares And Indices
5. Models And Assumptions

Ref Book – 1 (Page numbers – 1 to 19)

Chapter 2:: Deterministic Cash Flows **[12Hours]**

1. Net Present Value
2. Internal Rate of Return
3. A Comparison of IRR and NPV
4. Bonds: Price and Yield
5. Clean and Dirty Price
6. Price Yield Curves
7. Duration
8. Term Structure of Interest Rates
9. Immunisation
10. Convexity
11. Callable Bonds

Ref Book – 1 (Page numbers – 20 to 57)

Module - II

Chapter 3 :: Random Cash Flows **[11 Hours]**

1. Random Returns
2. Portfolio Diagrams And Efficiency
3. Feasible Set
4. Markowitz Model
5. Capital Asset Pricing Model

6. Diversification

7. CAPM as a rising formula

8. Numerical Technique

Ref Book – 1 (Page numbers – 59 to 95)

Chapter 4: Forwards And Futures [10 Hours]

1. Forwards and Futures
2. Forwards and Futures Price
3. Value of A Futures Contract
4. Method of Replicating Portfolios
5. Hedging with Futures
6. Currency Futures
7. Stock Index Futures

Ref Book – 1 (Page numbers – 97 to 117)

Reference Books:

The Calculus Of Finance - Amber Habib (Mathematical Sciences Foundation New Delhi)

Course Outcomes:

CO-1. Describe Arbitrage

CO-2. Can find Return And Interest

CO-3. Describe Bonds , Shares And Indices

CO-4. Describe Net Present Value

CO-5. Can find Price Yield Curves

CO-6. Describe Immunisation

SEMESTER I

Major Practical-1

Course Code: MTMAP-516 **Course Type - Practical**
Course Name:Practical on Linear Algebra and Group Theroy **Lectures allotted : 30**
Credits alloted - 2

Practical No. 1: Practical on Vector spaces, Subspaces.

Practical No. 2: Practical on Basis and Dimension

Practical No. 3: Practical on Linear Mappings.

Practical No. 4: Practical on Eigenvalues and Eigenvectors.

Practical No. 5: Practical on Triangularization and Jordan Canonical form

Practical No. 6: Practical on Bilinear form and Quadratic forms

Practical No. 7: Practical on Groups, Subgroups and Cyclic Groups

Practical No. 8 : Practical on Permutation Groups

Practical No. 9 : Practical on cosets, Lagrange's Theorem and External Direct Product.

Practical No.10 : Practical on Homomorphism and Isomorphism

Practical No.11 : Practical on Normal Subgroups.

Practical No. 12 : Practical on Fundamental Theorem of Finite Abelian group and Sylow Theorem

Course Outcomes :

CO 1: Solve problems related to vector spaces, Subspaces.
CO 2: Solve problems related to Linear Mappings.
CO 3: Use appropriate method to find eigen values and eigen vectors.
CO-4 : Find which groups are Cyclic Groups and which are Normal Subgroups.
CO-5 : Find even and odd permutations and Isomorphic groups.
CO-6 : Find cosets of subsets of a group and define External Direct Product

SEMESTER I

Major Practical No.02

Course Code: MTMAP-517 **Course Type: Practical**

Course Name: Practical on Advanced Calculus and Financial Mathematics
Lectures: 30

Credits alloted - 2

Practical No. 1: Practical on Directional Derivatives

Practical No. 2: Practical on line integral

Practical No. 3: Practical on Surface integral

Practical No. 4: Practical on Divergence th^{m}

Practical No. 5: Practical on Multiple integral

Practical No. 6: Practical on Multiple integral

Practical No. 7: Practical on Buying and Selling Stocks

Practical No. 8: Practical on Stock Valuation

Practical No. 9: Practical on Bond Valuation

Practical No. 10: Practical on Discount

Accumulation

Practical No. 11: Practical on Intrinsic Value Of Calls and Puts

Practical No. 12: Practical on Determinants of Option Value

Course Outcomes:

CO1: Solve Examples on line integrals and it's Applications
CO2: Describe the Parametric representation of surface integral,solve examples.
CO3: Explain the concept of transformation formula and solve examples.

CO4: Describe Arbitrage

CO5: Can find Return And Interest

CO6: Describe Immunisation

SEMESTER I

Elective Paper No. 6-A

Course Code: MTMAET-518-A **Course Type: Theory**

Course Name: Python Programming **Lectures: 30**

Credits alloted - 2

Module-I

Unit 1 : Conditional Statements **[3 Hours]**

1. if, if-else, and if-elif-else constructs.
2. The if-elif-else Ladder.
3. Logical Operators.
4. The Ternary Operator
5. The get Construct.
6. Examples

Ref Book – 1 (section numbers – 3.1 to 3.7)

Unit 2 : Looping **[3 Hours]**

1. While.
2. Patterns.
3. Nesting and Applications of Loops in Lists.

Ref Book – 1 (section numbers – 4.1 to 4.4)

Unit 3 : Functions **[3 Hours]**

1. Features of a functions: Modular Programming; Reusability of Code, Manageability.
2. Basic Terminology: Name of Functions; Arguments; Return Value.
3. Definition and Invocation: Working.
4. Type of Functions: Advantage of Arguments.

Ref Book – 1 (section numbers – 5.1 to 5.9)

Unit 4 : Iterations, Generators, and Comprehensions **[4 Hours]**

1. The Power of “For”.
2. Iterators.
3. Defining an Iterable Object.
4. Generators.

5. Comprehensions

Ref Book – 1 (section numbers – 6.1 to 6.6)

Module - II

Unit 5 : File Handling [4 Hours]

1. The File Handling Mechanism.
2. The Open Function and File Access Modes.
3. Python Functions for File Handling: The Essential Ones; The OS Methods; Miscellaneous Functions and File Attributes.
4. Command Line Arguments.
5. Implementation and Illustrations.

Ref Book – 1 (section numbers – 7.1 to 7.6)

Unit 6 : Strings [4 Hours]

1. The Use of "For" and "While"
2. String Operators: The Concatenation Operator (+); The Replication Operator; The Membership Operator
3. Functions for String Handling: len(); Capitalize(); find(); count; Endswith(); Encode; Decode; Miscellaneous Function

Ref Book – 1 (section numbers – 8.1 to 8.4)

Unit 7 : Introduction to Object Oriented Paradigm [4 Hours]

1. Creating New Types.
2. Attributes and Functions: Attributes; Functions.
3. Elements of Object- Oriented Programming: Class; Object; Encapsulation; Data Hiding;
4. Inheritance; Polymorphism; Reusability

Ref Book – 1 (section numbers – 9.1 to 9.4)

Unit 8 : Classes and Objects [5 Hours]

1. Defining a Class.
2. Creating an Object.
3. Scope of Data Members.
4. Nesting.
5. Constructor.
6. Constructor Overloading.
7. Destructors.

Ref Book – 1 (section numbers – 10.1 to 10.8)

Reference Books:

1. Python Basics by H. Bhasin
2. MERCURY LEARNING AND INFORMATION Dulles, Virginia Boston, Massachusetts New Delhi Chapter 1: 1.2, 1.4, 1.5. Chapter 2: 2.2 to 2.4. Chapter 3: 3.2 to 3.7;Chapter 4: 4.2 to 4.4. Chapter 5: 5.2, to 5.8. Chapter 6: 6.2 to 6.6. Chapter 7: 7.1, to 7.6; Chapter 8: 8.1, to 8.4. Chapter 9: 9.1, 9.2, 9.3, 9.4. Chapter 10: 10.1, to 10.8.; Chapter 11: 11.1to 11.5. Chapter 12: 12.2, to 12.8.; Chapter 13: 13.2, to 13.6.
3. Beginning-Python, Second Edition by Magnus Lie Hetland
4. The Complete Reference Python by Martin C. Brown
5. Head First Python by Patrick Barry
6. Learning Python, O‟Reilly by Mark Lutz
7. Python in a Nutshell, O‟Reilly by Alex Martelli

Course Outcomes :

CO 1: Define and understand the terms strings, tuple, list.

CO 2: Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements.

CO 3: Express proficiency in the handling of strings and functions

CO 4: Determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets.

CO 5: Describe the concept of classes and objects

CO 6: Implement Conditionals and Loops for Python Programs

SEMESTER I

Elective Paper No. 3-A (Practical)

Course Code: MTMAEP-519-A **Course Type:Practical**

Course Name: Practical on Python Programming **Lectures-30**

Credit alloted :2

Practical No. 1: Practical on Conditional Statements

Practical No. 2: Practical on Looping.

Practical No. 3: Practical on Strings

Practical No. 4: Practical on File Handling

Practical No. 5: Practical on Functions.

Practical No. 6: Practical on Iterations, Generators, and Comprehensions.

Practical No. 7: Practical on Iterations, Generators, and Comprehensions

Practical No. 8: Practical on Classes and Objects

Practical No. 9: Practical on Object Oriented Paradigm

Practical No. 10: Practical on List and tuples.

Practical No. 11: Practical on AP and GP using generators

Practical No. 12: Practical on AP and GP using Loop

Course Outcomes:

CO 1: Define and understand the terms strings, tuple, list.

CO 2: Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements.

CO 3: Express proficiency in the handling of strings and functions

CO 4: Determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets.

CO 5: Describe the concept of classes and objects

CO 6: Implement Conditionals and Loops for Python Programs

SEMESTER I

Elective Paper No. 6-B

Course Code: MTMAET-518 B **Course Type:Theory**
Course Name: Dynamical System **Lectures: 30**

Credit alloted-2

Unit 1: Eigenvalues and Eigenvectors [04 Lectures]

1.1 Eigenvalues and Eigenvectors

1.2 Diagonalisation (matrices with real and distinct eigenvalues)

Ref Book – 1 (Page numbers – 82 to 88)

Unit 2: First-Order Equations and Planar Linear Systems [8 Lectures]

2.1 The Simplest Example

2.2 The Logistic Population Model

2.3 Second-Order Differential Equations

2.4 Planar Systems

2.5 Preliminaries from Algebra

2.6 Planar Linear Systems

2.7 Eigenvalues and Eigenvectors

2.8 Solving Linear Systems

2.9 The Linearity Principle.

Ref Book – 1 (Page numbers – 01to 38)

Unit 3: Phase Portraits for Planar Systems [07 Lectures]

3.1 Real Distinct Eigenvalues

3.2 Complex Eigenvalues

3.3 Repeated Eigenvalues

3.4 Changing Coordinates

Ref Book – 1 (Page numbers39 – to 59)

Unit 4: Classification of Planar Systems and Exponential of a matrix [07 Lectures]

1.1 The Trace-Determinant Plane

1.2 Exponential of a matrix.

1.3 Dynamical classification

1.4 Exploration: 3D parameter space

Ref Book – 1 (Page numbers – 61 to 72)

Reference Books:

1.Differential Equations , Dynamical Syatems, and Introduction to Chaos: Morris W.Hirsch, Stephen Smale , Robert L. Devaney

Course Outcomes :

CO 1: Solve problems related to Eigenvalues and Eigenvectors.

CO 2: Use Second-Order Differential Equations to solve systems

CO 3: Use Linearity principle to solve the systems.

CO 4: Solve problems related to phase portrait for linear systems

CO 5: Use Dynamical classifications and study 3D parameter space

CO 6: To study Higher Dimensional Linear Algebra and solve problems related to eigen values and eigenvectors.

SEMESTER I

Elective Practical Paper No.3 B

Course Code: MTMAEP-519B **Course Type: Practical**

Course Name: Practical on Dynamical System **Lectures-30**

Credit alloted-2

Practical No. 1: Practical on Eigenvalues and Eigenvectors

Practical No. 2: Practical on Second-Order Differential Eqs.

Practical No. 3: Practical on Planar Systems

Practical No. 4: Practical on Solutions of Linear Systems

Practical No. 5: Practical on Phase Portraits with Real Distinct Eigenvalues

Practical No. 6: Practical on Phase Portraits for Planar Systems with Complex Eigenvalues

Practical No. 7: Practical on Exponential of a matrix.

Practical No. 8: Practical on Dynamical classification

Practical No. 9: Practical on Exploration: 3D parameter space

Practical No.10: Practical on Higher Dimensional Linear Algebra **(**Eigen values and Eigen vectors)

Practical No.11: Practical on Dynamical classification

Practical No. 12: Practical on Diagonalisation (matrices with real and distinct eigenvalues)

Course Outcomes :

CO 1: Solve problems related to floating point number system.

CO 2: Use appropriate pivoting strategies to solve system of linear equations and use iterative techniques for linear system of equations.

CO 3: Solve equations using fixed point iteration scheme and verify order of convergence.

CO 4: Apply the numerical methods to find eigenvalue and corresponding eigenvector of a Matrix.

CO 5: Reduce matrix to Symmetric Tridiagonal Form.

CO 6: Solve initial value problems using different methods and implement more accurate Method.

SEMESTER- II

Major Paper No: 07

Course Code: MTMAT- 521 **Course Type: Theory**
Course Name : Number Theory **Lectures: 30**
Credit alloted-2

Module-I

Unit 1: Congruences **[8 lectures]**

1.1 Divisibility
1.2 Prime
1.3 The Binomial Theorem
1.4 Congruence
1.5 Solution of congruences
1.6 The Chinese Remainder Theorem

Reference book-1(Chapter 1 (Sec 1.2 to 1.4), Chapter 2 (Sec 2.1 to 2.3))

Unit 2 : Quadratic Reciprocity and Quadratic Forms **[6 Lectures]**

2.1 Quadratic Residues
2.2 Quadratic Reciprocity
2.3 The Jacobi symbol

Reference book-1(Chapter 3 (Sec 3.1 to 3.3))

Module-II

Unit 3 : Some Functions of Number Theory **[6 Lectures]**

3.1 Greatest Integer Function
3.2 Arithmetic Functions
3.3 The Mobius Inversion Formula

Reference book-1(Chapter 4 (Sec 4.1 to 4.3))

Unit 4 : Algebraic Numbers **[10 Lectures]**

4.1 Polynomials
4.2 Algebraic Numbers
4.3 Algebraic Number Fields
4.4 Algebraic Integers
4.5 Diophantine Equation

Reference book-1(Chapter 9 (Sec 9.1 to 9.5))

Reference Books:

1. **Ivan Niven; Herbert Zuckerman; Hugh Montgomery: An Introduction to Theory of Numbers, John Wiley and Sons, 5th Edition.**

   Unit 1 : Chapter 1 (Sec 1.2 to 1.4), Chapter 2 (Sec 2.1 to 2.3)

   Unit 2 : Chapter 3 (Sec 3.1 to 3.3)

   Unit 3 : Chapter 4 (Sec 4.1 to 4.3)

   Unit 4 : Chapter 9 (Sec 9.1 to 9.5)

Course Outcomes :

CO-1 : Define divisibility, primes and Congruences.

CO-2 : Define Quadratic Residue modulo n, Legendre symbol and Jacobi Symbol.

CO-3 : State and Prove Quadratic Reciprocity.

CO-4 : Define different functions on Number Theory.

CO-5 : State and prove Mobius Inversion Formula using concept of Mobius mu Function

CO-6 : Define and Identify Algebraic Numbers and Algebraic Integers.

SEMISTER-II

Major Paper No. 08

Course Code: MTMAT-522 **Course Type : Theory**

Course Name : Ring Theory

Credits Allotted : 2 **Lectures allotted:30**

Module I

Unit 1: Rings **[4 hours]**

1. Terminology;
2. Rings of continuous functions, Polynomial rings, Matrix rings
3. Special rings, Boolean rings, Direct products.
4. Characteristics of ring.

Ref Book – 1 (Page numbers – 3 to 16 & 19 to 22 & 24)

Unit 2: Ideals **[6 hours]**

1. Definitions and basic properties of ideals.
2. Algebra of ideals.
3. Quotient rings and ideals in quotient rings.

Ref Book – 1 (Page numbers – 33 to 57)

Module II

Unit 3: Homomorphism of Rings **[8 hours]**

1. Fundamental theorems
2. Endomorphism Rings
3. Field of Fractions, Prime fields.

Ref Book – 1 (Page numbers – 67 to 87)

Unit 4: Factorization in Domains **[12 hours]**

1. Division in Domains
2. Euclidean Domains
3. Principal Ideal Domains
4. Factorization Domains
5. Unique Factorization Domains
6. Eisenstein's Criterion.

Ref Book – 1 (Page numbers – 89 to 111)

Reference Books:

1. **C. Musili, Rings and Modules**, 2nd Revised Edition, Narosa Publishing

House. (Chapters 1, 2, 3, 4)

Reference Books:

1 **Joseph.A.Gallian,** Contemporary Abstract Algebra, fourth edition, Narosa Publishing House.

Course Outcomes :

CO 1: Define the terms ring, subring, integral domain, Field, Different types of Rings, ideals.

CO 2: Solve examples of ideals, prime, principal and maximal ideals.

CO 3: Compare the concept of integral domain, Field

CO 4: Identify homomorphism, endomorphism between rings.

CO 5: Illustrate theorems on UID, PID , factor ring and UFD.

CO 6: Justify concepts in Ring theory by giving counter example

SEMESTER- II

Major Paper No-9

Course Code: MTMAT-523 **Course Type - Theory**

Course Name : Measure and Integration **Lectures allotted : 30**

Credits alloted - 2

Module I

Unit-I Lebesgue Measure **[10Hours]**

1.1 Lebesgue Outer Measure
1.2 σ- algebra of Lebesgue Measurable sets
1.3 Outer and Inner Approximation of Lebesgue Measurable Sets
1.4 Countable Additivity
1.5 Continuity
1.6 Borel-Cantelli Lemma
1.7 Non-measurable Set, Cantor Set**,** Cantor-Lebesgue Function.
Ref.Book-1 (Page numbers 2 to 53)

Unit-II. Lebesgue Measurable Functions:. **[10Hours]**

2.1 Definition and algebra of Lebesgue Measurable Functions
2.2 Sequential Point wise Limits and Approximations by Simple Functions
2.3 Littlewoods's Three Principles
2.4 Egoroff's Theorem
2.5 Lusin's Theorem.
Ref.Book-1 (Page numbers 54 to 67)

Module II

Unit-III. Differentiation and Integration: **[10 Hours]**

3.1 Continuity of Monotone Functions
3.2 Lebesgue's Differentiation Theorem
3.3 Functions of Bounded Variation
3.4 Jordan's Theorem, Absolutely Continuous Functions
3.5 Integration of Derivatives

3.6 Differentiation of Indefinite Integral
Ref.Book-1 (Page numbers 107 to 134)

Reference Books:

Real Analysis-Fourth Edition, Authors**: H. L. Royden, P. M. Fitzpatrick.**
Sections: Chapter 2, chapter 3, chapter 6

Course Outcomes :

CO1: Define Lebesgue measure, outer measure, Lebesque measurable Functions.

CO2: Describe cantor set, Non measurable set, cantor-lebesgue function, Borel-Cantelli's Lemma

CO3: Extract result of Differentiation and Integrations

CO4: Check sets and functions are measurable or not

CO5: Calculate measure of countable sets, uncountable sets, intervals

CO6: Explain Littlewood's Three Principles, Egoroff's Theorem theorem, Lusin's Theorem, jordan's theorem

SEMESTER- I

Major Paper No: 10

Course Code:MTMAT-524 **Course Type : Theory**
Course Name: Partial Differential Equations **Lectures - 30**
Credit alloted - 2

MODULE-I

Unit 1 :Introduction to partial differential equations of first Order. **[6 Lectures]**

1. Genesis of first order P.D.E.
2. Compatible systems
3. Charpit's method
4. Jacobi's method
5. Non Linear first order P.D.E

Ref.Book-1 (Page numbers 3 to 7 , 23 to 40 and 57 to 73)

Unit 2 : Fundamental Concepts. [**8 lectures**]

1. First order partial differential equations
2. Classification of Second Order P.D.E.
3. Canonical Forms, Canonical Form for Hyperbolic Equation , Canonical Form for Parabolic Equation , Canonical Form for Elliptic Equation.
4. General Method to Finding CF of Reducible and Irreducible Non-homogeneous Linear P.D.E.

Ref.Book-2(Page numbers 52 to 68 and 86 to 90)

MODULE-II

Unit 3 : Elptic And Parabolic Differential Equations **[10 lectures]**

1. Occurrence of the Laplace and Poisson Equations
2. Boundary Value Problems (BVPs)
3. Dirichlet Problem for a Rectangle
4. Occurrence of the Diffusion Equation and Elementary solution of the
5. Diffusion Equation
6. Dirac Delta Function
7. Separation of Variables Method (with examples)

Ref.Book-2(Page numbers 106 to 110,124 to 126,183 to 208)

Unit 4: Hyperbolic Differential Equations [**6 lectures**]

1. Occurrence of the Wave Equation
2. Derivation of One-dimensional Wave Equation
3. Solution of One-dimensional Wave Equation by Canonical Reduction
   Ref.Book-2(Page numbers 232 to 240 and 242)

Reference Books:

1. An Elementary Course in Partial Differential Equations, T Amarnath ,Narosa Publication (Chapter 1)
2. Introduction to Partial Differential Equations, K.Sankara Rao (Third Edition) PHI Learning Private Limited

Course Outcomes :

CO1 : Define First and Second order P.D.E, Order,Degree,Linear P.D.E,GEnesis of first & Second order

CO2 : Explain Method of Linear P.D.E with constant coefficient.

CO3 : Explain Compatible System for finding solution of P.D.E.

CO4 : Classify Second order P.D.E. in Canonical form & Canonical form for Parabolic , Hyperbolic, & Eliptic Equation

CO5 : Solve linear P.D.E using charpits and Jacobi's Method

CO6: Solve wave equation , Heat equation using separation method.

SEMESTER-II

Major Paper No:11

Course Code: MTMAT-525 **Course Type: Theory**
Course Name: Financial Mathematics-II **Lectures: 30**
Credit alloted - 2

Unit 1: Life Annuities **[8 Hours]**

1.1. Mortality Table

1.2. Commutation Terms

1.3. Pure Endowment

1.4. Types of Life Annuities
Ref.Book-1(Page numbers 431 to 447)

Unit 2:: Life Insurance **[7Hours]**

2.1. Whole Life Insurance Policy

2.2. Annual Premium: Whole Life Basis

2.3. Annual Premium: m-Payment Basis

2.4. Deferred Whole Life Policy

2.5. Deferred Annual Premium: Whole Life Basis

2.6. Deferred Annual Premium: m-Payment Basis

Ref.Book-1(Page numbers 448 to 453)

Unit 3:: Policy And Premiums **[10 Hours]**

4.1 Term Life Insurance Policy

4.2 Endowment Insurance Policy

4.3 Annual Premium for the Endowment Policy

4.4 Less than Annual Premiums

4.5 Natural Premium vs. the Level Premium

4.6 Reserve and Terminal Reserve Funds

4.7 Benefits of the Terminal Reserve

4.8 How Much Life Insurance Should You Buy?

Ref.Book-1(Page numbers 454 to 469)

Unit 4:: Property and Casualty Insurance [5 Hours]

3.1. Deductibles and Co- Insurance

3.2. Health Care Insurance

3.3. Policy Limit

Ref.Book-1(Page numbers 470 to 476)

Reference Books:

1. Mathematical Finance - M. J. Alhabeed (A John Wiley and sons ,inc., Publications) **Course Outcomes:**

CO-1: Describe the Mortality Table

CO-2: Describe Annual premium on whole Life Basis

CO-3: Explain the Life Insurance Policy

CO-4: Using Life Insurance Policy Solve Problems on daily life.

CO-5: Explain the concept of Health care Insurance

CO-6: Describe the policy limit.

SEMESTER II

Major Practical No. 04

Course Code: MTMAP-526 **Course Type: Practical**

Course Name: Number Theory and Ring Theory **Lectures:30**

Credit allotted - 2

Practical No. 1: Practical on Divisibility

Practical No. 2: Practical on Congruence

Practical No. 3: Practical on Quadratic Reciprocity and Jacobi symbol

Practical No. 4: Practical on Functions of Number Theory

Practical No. 5: Practical on Algebraic Numbers.

Practical No. 6: Practical on Quadratic Fields.

Practical No. 7: Practical on examples of different rings.

Practical No. 8 : Practical on ideals, prime, principal and maximal ideals

Practical No. 9 : Practical on Homomorphism and endomorphism between Rings.

Practical No.10 : Practical on Field of Fractions, Prime fields.

Practical No.11 : Practical on Euclidean Domains and PID

Practical No.12 : Practical on FD, UFD and Eisenstein's Criterion.

Course Outcomes:

CO-1 : Solve examples of ideals, prime, principal and maximal ideals.

CO-2 : Solve examples on homomorphism and endomorphism.

CO-3 : Identify irreducible or reducible polynomials , solve examples on PID,UFD.

CO-4 : Solve Congruence and find Quadratic Residue modulo n, Legendre symbol and Jacobi symbol values.

CO-5 : Find values of different Arithmetic functions of Number Theory for any Integer.

CO-6 : Identify different Algebraic numbers and Algebraic Integers.

SEMESTER-II

Major Paper No:12 A

Course Code: MTMAT-524-B **Course Type: Theory**
Course Name: Integral Equations
Credit allotted- 2 **Lectures: 30**

Module-I

Unit 1: Introductory Concepts [10 Hours]

1. Definitions
2. Classification of Linear Integral Equations
3. Solution of an Integral Equation
4. Converting Volterra Equation to ODE
5. Converting IVP to Volterra Equation
6. Converting BVP to Fredholm Equation

Ref.Book-1(Section 1.1 to 1.6)

Unit 2: Fredholm Integral Equations [8 Hours]

1. Introduction
2. The Decomposition Method
3. The Direct Computation Method
4. The Successive Approximation Method
5. The Method of Successive Substitutions
6. Comparison between Alternative Methods

Ref.Book-1(Section 2.1, 2.2, 2.4 to 2.7)

Module-II

Unit 3: Volterra Integral Equations [8 Hours]

1. **I**ntroduction
2. The Decomposition Method
3. The Series Solution Method
4. Converting Volterra Equation to IVP
5. The Successive Approximation Method
6. The Method of Successive Substitutions
7. Comparison between Alternative Methods
8. Volterra Equation of the First Kind

Ref.Book-1(Section 3.1, 3.2, 3.4 to 3.9)

Unit4: Fredholm Integro-Differential Equations [4 Hours]

1. Introduction
2. Fredholm Integro-Differential Equations
3. The Direct Computation Method
4. The Adomian Decomposition Method

Ref.Book-1(Section 4.1 to 4.4)

Reference Books:

1. **Abul-Majid Wazwaz,** A First Course In Integral Equations, World Scientific Publications, 1997. Chapter-1 -4.

2. **Dr. M.D. Raisinghania :** Integral Equations and Boundary value problems. , S.Chand Publishing

3. **Shanti Swarup , Shiv Raj Singh :** Integral Equations , Krishna's Educational Publishers,1942.

Course Outcomes:

CO-1: Define integral equations and linear integral equations and their types

CO-2: Describe the convergence of integral equations

CO-3: Explain the Fredholm and Volterra integral equations

CO-4: Using Decomposition Method to solve the Fredholm and Volterra integral equations

CO-5: Explain the concept of Homogeneous Fredholm Equations

CO-6: Apply the Green's Function to solve the integral equations

SEMISTER II

Elective Practical Paper No. 6-A

Course Code: MTMAEP- 529-A **CourseType:Practical**

Course Name: Practical on Financial Mathematics **Lectures: 30**

Credit alloted - 2

Note : Each lecture is of 1 hour

Practical No. 1: Practical on Mortality Table
Practical No. 2: Practical on Commutation Terms
Practical No. 3: Practical on Pure Endowment
Practical No. 4: Practical on Types of Life Annuities
Practical No. 5: Practical on Whole Life Insurance Policy
Practical No. 6: Practical on Endowment Insurance Policy
Practical No. 7: Practical on Annual Premium: m-Payment Basis
Practical No. 8: Practical on Deferred Whole Life Policy
Practical No. 9: Practical on Term Life Insurance Policy
Practical No. 10: Practical on Reserve and Terminal Reserve Funds
Practical No. 11: Practical on Deductibles and Co- Insurance
Practical No. 12: Practical on Health Care Insurance

Course Outcomes :

CO-1: Describe the Mortality Table

CO-2: Describe Annual premium on whole Life Basis

CO-3: Explain the Life Insurance Policy

CO-4: Using Life Insurance Policy Solve Problems on daily life.

CO-5: Explain the concept of Health care Insurance

CO-6: Describe the policy limit.

SEMESTER- II
Elective Paper No. 12-B

Course Code: MTMAET-528-B **Course Type - Theory**

Course Name: Cryptography **Lectures :30**

Credits Allotted -2

Module -I

Unit 1 : Encryption **[10 Hours]**

1. Encryption Schemes
2. Symmetric and Asymmetric Crypto Systems
3. Cryptanalysis
4. Alphabets and words
5. Permutations

Reference Book-1 (page numbers 71 to 80)

Unit 2 : Secret Key Encryption **[10 Hours]**

1. Perfect Secrecy - One time pads
2. Stream ciphers and the Data Encryption Standard (DES)
3. The Advanced Encryption Standard (AES)

Reference Book-1 (page numbers 119, 127 to 138 and 139 to 146)

Module - II

Unit 3 : . Public Key Encryption **[10 Hours]**

1. Factoring and the RSA encryption
2. Discrete log. Diffie-Hellman Key Exchange
3. ElGamal encryption
4. Digital Signatures
5. One-time signatures
6. Rabin and ElGamal signatures schemes, Digital Signature Standard (DSS).

Reference Book-1 (page numbers 163 to 198)

Reference Books:

1. **Johannes A**. **Buchmann,** Introduction to Cryptography, Second Edition Springer Publication
2. **D. R. Stinson** : CRYPTOGRAPHY: Theory and Practice. CRC Press. 1995.

Course Outcomes :

CO 1: To understand basics of Cryptography

CO 2: Analyze and design classical encryption techniques and block ciphers.

CO 3: Understand and analyze data encryption standard.

CO 4: Understand key management and distribution schemes and design User Authentication

CO 5: Understand and analyze public-key cryptography, RSA and other public-key cryptosystems

CO 6: Understand Secret Key Encryption

SEMISTER II

Elective Practical Paper No. 6-B

Course Code: MTMAEP- 529-B **CourseType:Practical**

Course Name :Cryptography **Lectures: 30**

Credit alloted - 2

Note : Each lecture is of 1 hour

Practical No. 1: Practical on Classical cryptography

Practical No. 2: Practical on Stream ciphers and the Data Encryption Standard (DES)

Practical No. 3: Practical on Perfect Secrecy - One time pads

Practical No. 4: Practical on The Advanced Encryption Standard (AES)

Practical No. 5: Practical on Definition. Shamir's threshold scheme, Visual secret sharing schemes.

Practical No. 6: Practical on Factoring and the RSA encryption

Practical No. 7: Practical on Discrete log. Diffie-Hellman Key Exchange

Practical No. 8: Practical on Digital Signatures, One-time signature

Practical No. 9: Practical on Cryptographically Secure Hashing.

Practical No. 10: Practical on Message Authentication Codes

Practical No. 11: Practical on HMAC, Network Security .

Practical No. 12: Practical on Secure Socket Layer, I Psec., Secret Sharing.

Course Outcomes:

CO 1: To understand basics of Cryptography

CO 2: Analyze and design classical encryption techniques and block ciphers.

CO 3: Understand and analyze data encryption standard.

CO 4: Understand key management and distribution schemes and design User Authentication

CO 5: Understand and analyze public-key cryptography, RSA and other public-key cryptosystems

CO 6: Understand Secret Key Encryption

SEMESTER-I

NEP-2020: First Year PG Major Mathematics

Research Methodology

Course Code MTRMT-577

Course Title: Research Methodology **Lectures allotted: 60**

Credits allotted -4

Unit 1. Foundations of Research: **[10 Hours]**

Meaning, Objectives and types of Research, Research Approaches, Significance of Research, Research and scientific methods, Research process, Criteria for Good Research, Research Problem Identification, Techniques involved in Defining a Problem. Writing of Proofs, quantifiers etc.

Unit 2. Research Design: **[10 Hours]**

Meaning and need of Research Design, features of good Design, Important concepts related to Good Design, Different Research Designs, Basic principles of experimental Designs, Analysis of Literature Review – Primary and Secondary Sources, Web sources for critical Literature Review such as MathSciNet, ZMATH, Scop-us, Web of Science, reviewing literature and identifying research gaps.

Unit 3. Research Methods: **[10 Hours]**

Scientific methods, Logical Methods: Deductive, Inductive, logical methods. Quantitative research methods, Qualitative research methods, Data Collection Techniques, Surveys and questionnaires, Interviews and focus groups, Observations and case studies, Experimental methods, Data Analysis and Interpretation, Statistical analysis techniques in mathematics, Qualitative data analysis methods, Visualization and interpretation of results.

Unit 4. Research Writing and Presentation: **[10 Hours]**

Scientific/ technical Writing Structure and Components, Importance of Effective Communication.

Preparing Research papers for journals, Seminars and Conferences – Design of paper using TEMPLATE, Calculations of Impact factor of a journal, citation Index, ISBN & ISSN. Preparation of Project Proposal – Time frame and work plan – Budget and Justification – Preparation and Publication of Research paper, Thesis writing. Project Reports for various funding, Writing Statement of Purpose for PhD/Post Doc etc, Writing a review of paper, Presenting research findings orally and visually, Research Collaboration and Communication, Collaborative research practices, Effective communication in mathematical research, Participating in conferences and seminars,

Unit 5. Research Ethics and Responsible Conduct: [10 Hours]

Ethics and Ethical Issues – Ethical Committees – Commercialization – copy right – royalty – Intellectual Property rights and patent law – Track Related aspects of intellectual property Rights – Reproduction of published material – Plagiarism and software to detect plagiarism– Citation and Acknowledgement – Reproducibility and accountability.

Unit 6. Mathematical Software and Paraphrasing Software: [10 Hours]

Basic Latex, Beamer, Overleaf, Grammarly, QuillBot, ChatGPT, and SAGE. Particularly, introduction to SAGE: Overview of the SAGE software, installation, and user interface. Basic Algebraic Manipulations: Symbolic algebra, equations, simplifications, and algebraic manipulations. Calculus Computations: Differentiation, integration. Linear Algebra with SAGE: Matrix operations, solving linear systems, eigenvalue calculations. Discrete Mathematics with SAGE: Combinatorics, graph theory.

Course Assessment:

The course assessment will be done at the college/institute level that includes but is not limited to a combination of the following methods:

- Research proposals and progress reports
- Research presentations
- Critical analysis of published mathematical research papers
- Participation in class discussions and activities
- Final research project or paper

Note: The syllabus provided above is a general outline and can be adapted and expanded based on the specific requirements of the institution offering this subject in Mathematics Programme and the expertise of the instructor.

References:

- **Kothari, C.R.** (2008), Research Methodology: Methods and Techniques. Second Edition. New Age International Publishers, New Delhi.
- **Dilip Datta,** LaTeX in 24 Hours, A Practical Guide for Scientific Writing, Springer
- **Eva O. L. Lantsoght,** The A-Z of the PhD Trajectory -A Practical Guide for a Successful Journey, Springer Cham, 2018.

Course Outcomes: *the student will*

- develop a comprehensive understanding of different research methodologies and their applications in mathematics.
- cultivate critical thinking and analytical skills necessary for identifying research problems and formulating research questions.

- provide practical experience in designing experiments, collecting and analyzing data, and interpreting research results.
- foster effective communication skills for presenting research findings orally and in written form.
- promote ethical research practices and awareness of responsible conduct in mathematical research.