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 Program:

(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.

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 student 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)'.

(iii) 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).

(iv) 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 practical 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)

1-credit practical = 30 hours. Thus, 1 credit practical = 2 contact hours in laboratory

3. 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 hours.

Structure of the course B. Sc. Mathematics:

	Major, Major Elective and VSC Courses			
Semester	**Course Type**	**Course code**	**Generic Name**	**Title of the paper**
I	Major	MTMAT-111	Mathematics theory paper-1	Algebra-I
		MTMAT-112	Mathematics theory paper-2	Calculus-I
		MTMAP-113	Mathematics practical paper-1	Practical based on Algebra-I and Calculus-I
	VSC (Related to Major)	MTVST-111	Vocational Mathematics theory-I	Python Programming
	IKS	MTIKT-111	IKS theory-I	Vedic Mathematics
II	Major	MTMAT-121	Mathematics theory paper-3	Algebra-II
		MTMAT-122	Mathematics theory paper-4	Calculus-II
		MTMAP-123	Mathematics practical paper-2	Practical based on Algebra-II and Calculus-II
	VSC (Related to Major)	MTVSP-121	Vocational Mathematics Practical-I	Practical on Python Programming
III	Major	MTMAT-231	Mathematics theory paper-5	Multivariable Calculus
		MTMAT-232	Mathematics theory paper-6	Graph Theory
		MTMAT-233	Mathematics theory paper-7	Operation Research
		MTMAP-234	Mathematics practical paper-3	Mathematics Practical Based on Multivariable Calculus and Operation Research and

				Graph Theory.
	VSC (Related to Major)	MTVST-231	Vocational Mathematics theory-II	Numerical Analysis
IV	Major	MTMAT-241	Mathematics theory paper-8	Combinatorics
		MTMAT-242	Mathematics theory paper-9	Linear Algebra
		MTMAT-243	Mathematics theory paper-10	Ordinary Differential Equation
		MTMAP-244	Mathematics practical paper-4	Mathematics Practical Based on Linear Algebra
V	Major	MTMAT-351	Mathematics theory paper-11	Metric Spaces
		MTMAT-352	Mathematics theory paper-12	Real Analysis-I
		MTMAT-353	Mathematics theory paper-13	Group Theory
		MTMAP-354	Mathematics practical paper-5	Mathematics Practical Based on Real Analysis-I and Group Theory
		MTMAP-355	Mathematics practical paper-6	Machine Learning-I
	Major Elective	MTMAET-351A	Elective Mathematics theory paper-1-A	Ordinary Differential Equation
		MTMAET-351B	Elective Mathematics theory paper-1-B	Laplace Transform
		MTMAEP-352A	Elective Mathematics practical paper-1-A	Practical on Ordinary Differential Equation
		MTMAEP-352B	Elective Mathematics practical paper-1-B	Practical on Laplace Transform

	VSC (Related to Major)	MTVSP-352	Vocational Mathematics Practical-II	Practical on Latex
VI	Major	MTMAT-361	Mathematics theory paper-14	Complex Analysis
		MTMAT-362	Mathematics theory paper-15	Real Analysis-II
		MTMAT-363	Mathematics theory paper-16	Ring Theory
		MTMAP-364	Mathematics practical paper-7	Mathematics Practical Based on Real Analysis-II and Ring Theory
		MTMAP-365	Mathematics practical paper-8	Machine Learning-II
	Major Elective	MTMAET-363A	Elective Mathematics theory paper-2-A	Optimization Techniques
		MTMAET-363B	Elective Mathematics theory paper-2-B	Partial Differential Equations
		MTMAEP-364A	Elective Mathematics practical paper-2-A	Practical on Optimization Techniques
		MTMAEP-364B	Elective Mathematics practical paper-2-B	Practical on Partial Differential Equations
VII	Major	MTMAT-471	Mathematics theory paper-17	Linear Algebra
		MTMAT-472	Mathematics theory paper-18	Group Theory
		MTMAT-473	Mathematics theory paper-19	Advanced Calculus
		MTMAT-474	Mathematics theory paper-20	Ordinary Differential Equations
		MTMAT-475	Mathematics theory paper-21	Financial Mathematics-I
		MTMAP-476	Mathematics practical paper-11	Mathematics Practical Based on Linear Algebra and Group Theory

		MTMAP-477	Mathematics practical paper-12	Mathematics Practical Based on Advanced Calculus and Financial Mathematics-I
	Major Elective	MTMAET-475-A	Elective Mathematics theory paper-3-A	Python Programming
		MTMAET-475-B	Elective Mathematics theory paper-3-B	Dynamical Systems
		MTMAEP-476-A	Elective Mathematics practical paper-4-A	Practical on Python Programming
		MTMAEP-476-B	Elective Mathematics practical paper-4-B	Practical on Dynamical Systems
	RM	MTRMT-471		Research Methodology
VIII	Major	MTMAT-481	Mathematics theory paper-22	Number Theory
		MTMAT-482	Mathematics theory paper-23	Ring Theory
		MTMAT-483	Mathematics theory paper-24	Measure and Integration
		MTMAT-484	Mathematics theory paper-25	Partial Differential Equations
		MTMAT-485	Mathematics theory paper-26	Integral Equations
		MTMAP-486	Mathematics practical paper-13	Mathematics Practical Based on Number Theory and Ring Theory
		MTMAP-487	Mathematics practical paper-14	Mathematics Practical Based on Measure and Integration and Partial Differential Equations
	Major Elective	MTMAET-487-A	Elective Mathematics theory paper-5-A	Financial Mathematics-II
		MTMAET-487-B	Elective Mathematics theory paper-5-B	Advanced Complex Analysis

		MTMAEP-488-A	Elective Mathematics practical paper-6-A	Practical on Financial Mathematics-II
		MTMAEP-488-B	Elective Mathematics practical paper-6-B	Practical on Advanced Complex Analysis
	On Job Training	MTOJT-481		
	Elective			
V		MTMAET-351A	Elective Mathematics theory paper-1-A	Ordinary Differential Equations
		MTMAET-351B	Elective Mathematics theory paper-1-B	Laplace Transform
		MTMAEP-352A	Elective Mathematics practical paper-1-A	Practical on Ordinary Differential Equations
		MTMAEP-352B	Elective Mathematics practical paper-1-B	Practical on Laplace Transformation
VI		MTMAET-363A	Elective Mathematics theory paper-2-A	Optimization Techniques
		MTMAET-363B	Elective Mathematics theory paper-2-B	Partial Differential Equations
		MTMAEP-364A	Elective Mathematics practical paper-2-A	Practical on Optimization Techniques
		MTMAEP-364B	Elective Mathematics practical paper-2-B	Practical on Partial Differential Equations
VII		MTMAET-475-A	Elective Mathematics theory paper-3-A	Python Programming
		MTMAET-475-B	Elective Mathematics theory paper-3-B	Dynamical Systems
		MTMAEP-476-A	Elective Mathematics practical paper-4-A	Practical on Dynamical Systems
		MTMAEP-476-B	Elective Mathematics practical paper-4-B	Practical on Python Programming

VIII		MTMAET-487-A	Elective Mathematics theory paper-5-A	Financial Mathematics-II
		MTMAET-487-B	Elective Mathematics theory paper-5-B	Advanced Complex Analysis
		MTMAEP-488-A	Elective Mathematics practical paper-6-A	Practical on Financial Mathematics-II
		MTMAEP-488-B	Elective Mathematics practical paper-6-B	Practical on Advanced Complex Analysis
	Vocational Skill Courses (VSC) Related to Major			
I		MTVST-111	Vocational Mathematics theory-I	Python Programming
II		MTVSP-121	Vocational Mathematics Practical-I	Practical on Python Programming
III		MTVST-231	Vocational Mathematics Practical-II	Numerical Analysis
IV		--------	----------	----------
V		MTVSP-352	Vocational Mathematics Practical-II	Practical on Latex
VI		-------	----------	----------
	Minor Mathematics			
I		-------	--------	---------
II		MTMIT-121	Minor Mathematics Theory-1	Linear Algebra
III		MTMIT-231	Minor Mathematics Theory-2	Discrete Mathematics
		MTMIP-232	Minor Mathematics Practical-1	Practical on Discrete Mathematics
IV		MTMIT-241	Minor Mathematics Theory-3	Calculus

		MTMIP-242	Minor Mathematics Practical-2	Practical on Calculus
V		MTMIT-356	Minor Mathematics Theory-4	Numerical Techniques
		MTMIP-357	Minor Mathematics Practical-3	Practical on Numerical Techniques using Python
VI		MTMIP-368	Minor Mathematics Theory-5	Operation Research
		MTMIP-369	Minor Mathematics Practical-4	Practical on Operation Research using Python
	IKS Related to Mathematics Major			
I		MTIKT-111	Indian knowledge system Mathematics paper	Vedic Mathematics
	SEC for science faculty students from Mathematics discipline			
I	SEC	MTSET-111	Skill Mathematics Theory-I	Analytical Geometry of three Dimensions
II		MTSEP-121	Skill Mathematics Practical-I	Practical on Analytical Geometry of three Dimensions
III		------	-----	
IV		MTSET-241	Skill Mathematics Theory-I	Computational Geometry
	OE/GE			
I	GE/OE	MTGET-111	General Elective Theory-1	Quantitative Aptitude-I
I		MTGET-112	General Elective Practical-1	Basic Mathematics - I
II		MTGET-121	General Elective Theory-2	Quantitative Aptitude-II
II		MTGET-122	General Elective Practical -2	Basic Mathematics-II
III		MTGET-231	General Elective Theory-3	Basic Algebra
IV		MTGEP-241	General Elective Practical -3	Practical on Basic Algebra

	Major, Major Elective and VSC Courses			
Semester	**Course Type**	**Course code**	**Generic Name**	**Title of the paper**
I	Major	MTMAT-111	Mathematics theory paper-1	Algebra-I
		MTMAT-112	Mathematics theory paper-2	Calculus-I
		MTMAP-113	Mathematics practical paper-1	Practical based on Algebra-I and Calculus-I
	VSC (Related to Major)	MTVST-111	Vocational Mathematics theory-I	Python Programming
	IKS	MTIKT-111	IKS theory-I	Vedic Mathematics
II	Major	MTMAT-121	Mathematics theory paper-3	Algebra-II
		MTMAT-122	Mathematics theory paper-4	Calculus-II
		MTMAP-123	Mathematics practical paper-2	Practical based on Algebra-II and Calculus-II
	VSC (Related to Major)	MTVSP-121	Vocational Mathematics Practical-I	Practical on Python Programming
III	Major	MTMAT-231	Mathematics theory paper-5	Multivariable and Vector Calculus
		MTMAT-232	Mathematics theory paper-6	Operation Research
		MTMAP-233	Mathematics practical paper-3	Mathematics Practical Based on Multivariable and Vector Calculus
	VSC (Related to Major)	MTVSP-231	Vocational Mathematics theory-II	Practical on Numerical Analysis using Python

IV	Major	MTMAT-241	Mathematics theory paper-8	Discrete Mathematics (Graph Theory and Combinatorics)
		MTMAT-242	Mathematics theory paper-9	Linear Algebra
		MTMAP-243	Mathematics practical paper-4	Mathematics Practical Based on Linear Algebra
V	Major	MTMAT-351	Mathematics theory paper-11	Metric Spaces
		MTMAT-352	Mathematics theory paper-12	Real Analysis-I
		MTMAT-353	Mathematics theory paper-13	Group Theory
		MTMAP-354	Mathematics practical paper-5	Mathematics Practical Based on Metric Spaces and Group Theory
		MTMAP-355	Mathematics practical paper-6	Machine Learning-I
	Major Elective	MTMAET-351A	Elective Mathematics theory paper-1-A	Ordinary Differential Equation
		MTMAET-351B	Elective Mathematics theory paper-1-B	Laplace Transform
		MTMAEP-352A	Elective Mathematics practical paper-1-A	Practical on Ordinary Differential Equation
		MTMAEP-352B	Elective Mathematics practical paper-1-B	Practical on Laplace Transform
	VSC (Related to Major)	MTVSP-352	Vocational Mathematics Practical-II	Latex
VI	Major	MTMAT-361	Mathematics theory paper-14	Complex Analysis
		MTMAT-362	Mathematics theory paper-15	Real Analysis-II

		MTMAT-363	Mathematics theory paper-16	Ring Theory
		MTMAP-364	Mathematics practical paper-7	Mathematics Practical Based on Complex Analysis and Ring Theory
		MTMAP-365	Mathematics practical paper-8	Machine Learning-II
	Major Elective	MTMAET-363A	Elective Mathematics theory paper-2-A	Optimization Techniques
		MTMAET-363B	Elective Mathematics theory paper-2-B	Partial Differential Equations
		MTMAEP-364A	Elective Mathematics practical paper-2-A	Practical on Optimization Techniques
		MTMAEP-364B	Elective Mathematics practical paper-2-B	Practical on Partial Differential Equations
VII	Major	MTMAT-471	Mathematics theory paper-17	Linear Algebra
		MTMAT-472	Mathematics theory paper-18	Group Theory
		MTMAT-473	Mathematics theory paper-19	Advanced Calculus
		MTMAP-474	Mathematics practical paper-11	Mathematics Practical Based on Linear Algebra and Group Theory
	Major Elective	MTMAET-471-A	Elective Mathematics theory paper-3-A	Ordinary Differential Equations
		MTMAET-471-B	Elective Mathematics theory paper-3-B	Financial Mathematics
	RM	MTRMT-471		Research Methodology
VIII	Major	MTMAT-481	Mathematics theory paper-22	Number Theory
		MTMAT-482	Mathematics theory paper-23	Ring Theory

		MTMAT-483	Mathematics theory paper-24	Measure and Integration
		MTMAP-484	Mathematics practical paper-13	Practical on Python Programming
	Major Elective	MTMAET-481-A	Elective Mathematics theory paper-5-A	Partial Differential Equations
		MTMAET-481-B	Elective Mathematics theory paper-5-B	Differential Geometry
	On Job Training	MTOJT-481		
	Elective			
V		MTMAET-351-A	Elective Mathematics theory paper-1-A	Ordinary Differential Equations
		MTMAET-351-B	Elective Mathematics theory paper-1-B	Laplace Transform
		MTMAEP-352-A	Elective Mathematics practical paper-1-A	Practical on Ordinary Differential Equations
		MTMAEP-352-B	Elective Mathematics practical paper-1-B	Practical on Laplace Transformation
VI		MTMAET-361-A	Elective Mathematics theory paper-2-A	Optimization Techniques
		MTMAET-361-B	Elective Mathematics theory paper-2-B	Partial Differential Equations
		MTMAEP-362-A	Elective Mathematics practical paper-2-A	Practical on Optimization Techniques
		MTMAEP-362-B	Elective Mathematics practical paper-2-B	Practical on Partial Differential Equations
VII		MTMAET-471-A	Elective Mathematics theory paper-3-A	Ordinary Differential Equations
		MTMAET-471-B	Elective Mathematics theory paper-3-B	Financial Mathematics
VIII		MTMAET-481-A	Elective Mathematics theory paper-5-A	Partial Differential Equations

		MTMAET-481-B	Elective Mathematics theory paper-5-B	Differential Geometry
	Vocational Skill Courses (VSC) Related to Major			
I		MTVST-111	Vocational Mathematics theory-I	Python Programming
II		MTVSP-121	Vocational Mathematics Practical-I	Practical on Python Programming
III		MTVSP-231	Vocational Mathematics Practical-II	Practical on Numerical Analysis using python
IV		--------	----------	----------
V		MTVSP-351	Vocational Mathematics Practical-II	Latex
VI		-------	----------	----------
	Minor Mathematics			
I		-------	--------	---------
II		MTMIT-121	Minor Mathematics Theory-1	Linear Algebra
III		MTMIT-231	Minor Mathematics Theory-2	Discrete Mathematics
		MTMIP-231	Minor Mathematics Practical-1	Practical on Discrete Mathematics
IV		MTMIT-241	Minor Mathematics Theory-3	Calculus
		MTMIP-241	Minor Mathematics Practical-2	Practical on Calculus
V		MTMIT-351	Minor Mathematics Theory-4	Numerical Techniques
		MTMIP-351	Minor Mathematics Practical-3	Practical on Numerical Techniques using Python

VI		MTMIT-361	Minor Mathematics Theory-5	Operation Research
		MTMIP-361	Minor Mathematics Practical-4	Practical on Operation Research using Python
	IKS Related to Mathematics Major			
I		MTIKT-111	Indian knowledge system Mathematics paper	Vedic Mathematics
	SEC for science faculty students from Mathematics discipline			
I	SEC	MTSET-111	Skill Mathematics Theory-I	Analytical Geometry of three Dimensions
II		MTSEP-121	Skill Mathematics Practical-I	Practical on Analytical Geometry of three Dimensions
III		------	-----	
IV		MTSET-241	Skill Mathematics Theory-I	Computational Geometry
	OE/GE			
I	GE/OE	MTGET-111	General Elective Theory-1	Quantitative Aptitude-I
		MTGET-112	General Elective Practical-1	Basic Mathematics - I
II		MTGET-121	General Elective Theory-2	Quantitative Aptitude-II
		MTGET-122	General Elective Practical -2	Basic Mathematics-II
III		MTGET-231	General Elective Theory-3	Basic Algebra
		MTGEP-231	General Elective Practical -3	Practical on Basic Algebra

SEMESTER-III

Major Paper No.: 01

Course Code: MTMAT-231 **Course Type: Theory**

Course Name: Multivariable Calculus

Credits: 2 **Lectures: 30**

Module-I

Unit-1 Limits and Continuity **[04 lectures]**

1.1 Functions of Several Variables
1.2 Domain and Range
1.3 Graphs, Level Curves,
1.4 Limits and Continuity of Functions of Three or More Variables

Unit-2 Partial Derivatives and Differentiability **[10 lectures]**

2.1 Definition and examples.
2.2 Higher Derivatives,
2.3 Clairaut's Theorem (Statement Only)
2.4 Partial Differential Equations, Wave equation.
2.5 Differentiable function,
2.6 Differentials
2.7 Chain Rule,
2.8 Homogeneous Functions and Euler's theorem

Module-II

Unit-3 Extreme Values **[08 lectures]**

3.1 Extreme values of functions of two variables.
3.2 Necessary conditions for extreme values.
3.3 Second Derivative Test (without proof).
3.4 Lagrange Multipliers (with one constraints)

Unit-4 Multiple Integrals **[08 lectures]**

4.1 Double and Triple Integral, Iterated Integrals, Fubini's Theorem (Statement only)
4.2 Double integral over general regions, Change of order of integration.
4.3 Double integral in Polar coordinates.
4.4 Jacobians, Change of variables in multiple integrals. (Results without proofs)

Reference Books:

Multivariable Calculus 7th Edition By James Stewart, Brooks/Cole, Cengage Learning, 2012, 2008.

Course Outcomes:

CO-1: Define Domain, Range, Graphs, Level curves, Limit and Continuity
CO-2: State Clairaut's theorem, Eulers theorem, Fubini's theorem.
CO-3: Use chain rule to find derivative of functions.
CO-4: Find solution of partial differential equations and multiple integrals.
CO-5: Solve Double and Triple integral, Iterated integrals.
CO-6: Apply Second derivative test to find extreme values of functions of two variable

SEMESTER-III

Major Paper No.: 02

Course Code: MTMAT-232 **Course Type: Theory**

Course Name: Graph Theory

Credits: 2 **Lectures: 30**

Module-I

Unit 1. Introduction **[08 Lectures]**

1.1 What is a Graph?

1.2 Application of Graphs

1.3 Finite and Infinite Graphs

1.4 Incidence and Degree

1.5 Isolated Vertex, Pendant Vertex and Null Graph

(Reference Book-1: Sec 1.1 to 1.5)

Unit 2. Paths and Circuits **[12 Lectures]**

2.1 Isomorphism

2.2 Subgraphs

2.3 Walks, Paths, and Circuits

2.4 Connected Graphs, Disconnected Graphs, and Components

2.5 Euler Graphs

2.6 More on Euler Graphs

2.7 Hamiltonian Paths and Circuits

2.8 The Traveling Salesman Problem

(Reference Book-1: Sec 2.1, 2.2, 2.4, 2.5, 2.6, 2.8, 2.9, 2.10)

Module-II

Unit 3. Trees and Fundamental Circuits **[12 Lectures]**

3.1 Trees

3.2 Some Properties of Trees

3.3 Pendant Vertices in a Tree

3.4 Distance and Centers in a Tree

3.5 Rooted and Binary Trees

3.6 On Counting Trees
3.7 Spanning Trees
3.8 Fundamental Circuits
(Reference Book-1: Sec 3.1 to 3.8)

Reference Books:

1. **Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science" Printice-Hall, of India Pvt. Lt. New Delhi.**

Course Outcomes:

CO-1: Define Graphs, Subgraphs, Tree, Vertex, Degree.
CO-2: State properties of Trees.
CO-3: Use Traveling Salesman Problem for finding shortest distance.
CO-4: Find distance and centres in a tree.
CO-5: Describe Eulers graphs, connected graphs and disconnected graphs.
CO-6: Apply some algorithm to find shortest distance and spanning tree.

SEMESTER-III

Major Paper No: 03

Course Code: MTMAT-233 **Course Type: Theory**

Course Name: Operation Research

Credits: 2 **Lectures: 30**

Module-I

Unit I – Modeling with Linear Programming: **[6 Hours]**

1.1 Two variable LP Model.

1.2 Solution of LP Model by Graphical Method.

Unit II- The Simplex Method and Duality: **[10 Hours]**

2.1 LP Model in equation form

2.2 Transition from graphical to algebraic solutions

2.3 The Simplex method.

2.4 Definition of the dual problem

2.5 Primal dual relationship

Module-II

Unit III - Transportation Model: **[8 Hours]**

3.1 Definition of the Transportation model

3.2 The Transportation algorithm.

Unit IV - The Assignment Model: **[6 Hours]**

4.1 The Hungarian method.

4.2 Simplex explanation of the Hungarian method.

Reference Books:

1. **J K Sharma, Operations Research (Theory and Applications, Latest Edition), Macmillan India Ltd.**

Course Outcomes:

CO-1: Define linear programming, transportation problem, simplex method.
CO-2: State Dual problem, Hungarian method.
CO-3: Use North West, Least cost, VAM to find solution of transportation problem.
CO-4: Find solution of simplex method.
CO-5: Describe graphical method of LPP.
CO-6: Apply some algorithm to find the assignment problem.

SEMESTER-III

Major Practical Paper No: 01

Course Code: MTMAP-234 **Course Type: Practical**

Course Name: Mathematics Practical based on Multivariable Calculus, Graph Theory and Operation Research

Credits: 2 **Practical: 12**

Practical No. 1: Practical on Limit and Continuity.
Practical No. 2: Practical on Partial Derivatives and Differentiability.
Practical No. 3: Practical on Extreme Values.
Practical No. 4: Practical on Multiple Integrals.
Practical No. 5: Practical on Graphs.
Practical No. 6: Practical on Paths.
Practical No. 7: Practical on Circuits.
Practical No. 8: Practical on Trees and Fundamental Circuits.
Practical No. 9: Practical on Linear Programming.
Practical No.10: Practical on The Simplex Method and Duality.
Practical No.11: Practical on Transportation Model.
Practical No. 12: Practical on The Assignment Model.

Course Outcomes:

CO-1: Define Domain, Range, Graphs, Level curves, Limit and Continuity, Trees

CO-2: Describe Euler's graphs, connected graphs and disconnected graphs.

CO-3: Use Traveling Salesman Problem for finding shortest distance.

CO-4: Find solution of partial differential equations and multiple integrals.

CO-5: Solve Double and Triple integral, Iterated integrals.

CO-6: Apply some algorithm to find the assignment problem.

SEMESTER-III

Vocational Mathematics Practical Paper No: 01

Course Code: MTVST-231 **Course Type: Theory**

Course Name: Numerical Analysis

Credits: 2 **Lectures: 30**

Module-I

Unit-1: Errors and Solution of Equations [4 lectures]

1. Rounding off numbers to n significant digits, to n decimal places.
2. Absolute, relative and percentage errors.
3. Location of roots.
4. Regula Falsi theorem.
5. Newton- Raphson Method.

Unit-2: Fitting of Polynomials [6 lectures]

1. Least Square Method.
2. Fitting of
   (i) Straight Line.
   (ii) Second Degree Curve.

Module-II

Unit-3: Interpolation [12 lectures]

1. Operators Δ, ∇, E and their relations.
2. Fundamental theorem of difference calculus.
3. Newton's Interpolation Formulae (Forward and Backward with proofs).
4. Lagrange's Interpolation Formula with proof.

Unit-4: Numerical Integration: [8 lectures]

1. General quadrature formula.
2. Trapezoidal rule.
3. Simpsons's $1/3^{rd}$ rule.
4. Simpsons's $3/8^{th}$ rule.

Unit-5: Numerical solution of first order ordinary differential equations [6 lectures]

1. Euler's method.
2. Modified Euler's methods.
3. Runge - Kutta Methods 2^{nd} and 4^{th} order.

Reference Books:

(1) H.C. Saxena; Finite differences and Numerical Analysis, S. Chand and Company.

(2) S.S. Sastry; Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India, 1999.

Note: Refer to S.S. Sastry for Chapter 1. Remaining Chapters from H.C.Saxena.

Course Outcomes:

CO-1: Define Errors, operators and General quadrature formula.
CO-2: Acquire basic knowledge in solving interpolation with equal interval problems by various numerical methods. Estimate the missing terms through interpolation methods.
CO-3: Develop skills in analyzing the methods of interpolating a given data, properties of interpolation with unequal intervals and derive conclusions, approximate a function using an appropriate numerical method.
CO-4: Implement numerical methods for a variety of multidisciplinary applications and a variety of numerical algorithms using appropriate technology.
CO-5: Use Tarpezoidal rule, Simpsons one third rule and three eight rule to find numerical integration.
CO-6: Apply Eulers and Modified Euler's method to find solution of first order ddifferential equation.

SEMESTER-III

Minor Mathematics Paper: 01

Course Code: MTMIT-231 **Course Type: Theory**

Course Name: Discrete Mathematics

Credits: 2 **Lectures: 30**

Module-I

Unit 1: Logic (7 Lectures)

1.1 Revision: Propositional Logic, Propositional Equivalences.
1.2 Rules of Inference: Argument in propositional Logic, Validity Argument (Direct and Indirect methods) Rules of Inference for Propositional Logic, Building Arguments.
1.3 Predicates and Quantifiers: Predicate, n-Place Predicate or, n-array Predicate, Quantification and Quantifiers, Universal Quantifier, Existential Quantifier, Quantifiers with restricted domains, Logical Equivalences involving Quantifiers.

Reference Book 1: Chapter 1: Sec. 1.1, 1.2, 1.3, 1.4, 1.5(Page no 1 to 73)

Unit 2: Sets, Relations and Lattices (7 Lectures)

1.1 Relations, types of relations, equivalence relations, Partial ordering relations
1.2 Digraphs of relations, matrix representation and composition of relations.
1.3 Transitive closure and Warshall's Algorithm
1.4 Poset, Hasse diagram.
1.5 Lattices, Complemented lattice, Bounded lattice and Distributive lattice.

Reference Book 2: Chapter 6: Sec. 6.1, 6.2, 6.3 (page no 218 to 242)

Module-II

Unit 3: Counting Principles (8 Lectures)

3.1 Cardinality of Set: Cardinality of a finite set.
3.2 Basics of Counting: The Product Rule, The Sum Rule, The Inclusion-Exclusion Principle.
3.3 The Pigeonhole Principle: Statement, the Generalized Pigeonhole Principle, Its Applications.
3.4 Generalized Permutations and Combinations : Permutation and Combination with Repetitions, Permutations with Indistinguishable Objects

Reference Book 1:(Chapter 2: Sec. 2.1 page no -122 to136, Chapter 5: Sec.5.1, 5.2, 5.3 page no -335 to 361)

Unit 4: Recurrence Relations (8 Lectures)

4.1 Recurrence Relations: Introduction, Formation.
4.2 Linear Recurrence Relations with constant coefficients.
4.3 Homogeneous Solutions.
4.4 Particular Solution
4.5 Total solution

Reference book 3: Chapter 10: Sec. 10.1, 10.2, 10.3, 10.4, 10.5(page no 306 to 319)

Reference Books:

1. **Discrete Mathematics and its applications, by Kenneth Rosen, Tata McGraw Hill, Seventh Edition**
2. **Discrete Mathematical Structures, by Kolman, Busby, Ross, Rehman, Prentice Hall 3.Elements of Discrete Mathematics, by C. L. Liu, Tata McGraw Hill.**

Course Outcomes:

CO-1: Recall basics of logics, permutations (arrangements), combinations (selections)
CO-2: Define concepts as Proposition, Quantifier, its types, Principle of Addition, Principle of multiplication
CO-3: Describe the methods to check validity of Argument
CO-4: Explain the truth values of predicates and quantifier, Validity of arguments and provide counter examples where necessary
CO-5: Apply the formula of Advanced counting technique to solve the problems
CO-6: Solve the sums based on counting, recurrence relations.

SEMESTER-III

Minor Practical Paper No.: 01

Course Code: MTMIP-232 **Course Type: Practical**

Course Name: Practical on Discrete Mathematics

Credits: 2 **Practical: 12**

Practical No. 1: Practical on Rules of Inference.
Practical No. 2: Practical on Predicates and Quantifiers.
Practical No. 3: Practical on Equivalence Relations and Partial order Relations.
Practical No. 4: Practical on Warshall's Algorithm, Poset and Hasse Diagram.
Practical No. 5: Practical on Lattices.
Practical No. 6: Practical on Counting Principles.
Practical No. 7: Practical on Permutation and Combinations.
Practical No. 8: Practical on Recurrence Relations-I.
Practical No. 9: Practical on Recurrence Relations-II.
Practical No. 10: Practical on Non-Homogeneous Recurrence Relations.
Practical No. 11: Practical on Pigeonhole Principle.
Practical No. 12: Practical on Propositional Logic.

Course Outcomes:

CO-1: Recall basics of logics, permutations (arrangements), combinations (selections)
CO-2: Define concepts as Proposition, Quantifier, its types, Principle of Addition, Principle of multiplication
CO-3: Describe the methods to check validity of Argument
CO-4: Explain the truth values of predicates and quantifier, Validity of arguments and provide counter examples where necessary
CO-5: Apply the formula of Advanced counting technique to solve the problems
CO-6: Solve the sums based on counting, recurrence relations.

SEMESTER-III

General Elective Paper No.: 01

Course Code: MTGET-231 **Course Type: Theory**

Course Name: Basic Algebra

Credits: 2 **Lectures: 30**

Module-I

Unit –I Matrices and Determinants **[08 Lectures]**

1. Definition of a Matrix and types of Matrices
2. Algebra of Matrices
3. Determinants
4. Adjoint of a Matrix, Inverse of a Matrix

(Ref Book No. 1)

Unit –II System of Linear Equations **[07 Lectures]**

1. Homogeneous System of Linear equations
2. Condition for Consistency of homogeneous system
3. Solution of Non-homogeneous System of Linear equations

(Ref Book No. 1)

Module -II

Unit –III Functions **[09 Lectures]**

1. Basic definitions
2. One-one, onto functions and Bijections
3. Composition of functions
4. Inverse of a function

(Ref Book No. 2)

Unit –IV Limits **[06 Lectures]**

1. Limits of functions
2. Limit theorems
3. Some extensions of limit concept

(Ref Book No. 3)

Reference Books:

1. A Textbook of Matrices by Shanti Narayan and P. K. Mittal, S Chand and Company Limited
2. A Foundation Course in Mathematics, Ajit Kumar, S. Kumaresan, Bhaba Kumar Sarma, Narosa Publication.
3. Introduction to Real Analysis: Robert G Bartle and Donald R Sherbert, 3rd edition, John Wiley and sons, Inc.

Course Outcomes:

CO-1: Define matrix, determinants, functions and Limit.
CO-2: State Homogeneous system of linear equations.
CO-3: Use some condition to find consistency of homogeneous system.
CO-4: Find solution of Non-homogeneous system of linear equations.
CO-5: Describe some extensions of limit concepts.
CO-6: Apply definition to prove limit and continuity theorem.

SEMESTER-IV
Major Paper No.: 01

Course Code: MTMAT-241 **Course Type: Theory**
Course Name: Combinatorics
Credit allotted: 2 **Lectures: 30**

Module-I

UNIT-1: Basic Counting Principles **[10 Lectures]**

1.1 Two Basic Counting Principles.
1.2 Simple Arrangements and Selections.
1.3 Arrangements and Selections with Repetitions.
1.4 Distributions.; Binomial Identities.
(Reference Book-2: Sec 5.1 to 5.5)

UNIT-2: Generating Functions **[06 Lectures]**

2.1 Generating Functions Models.
2.2 Calculating Coefficients of Generating Functions.
(Reference Book-2: Sec 6.1, 6.2)

Module-II

UNIT-3: Recurrence Relations **[12 Lectures]**

3.1 Recurrence Relations Models.
3.2 Solutions of Linear Recurrence Relations.
3.3 Counting with Venn Diagrams.
3.4 Inclusion-Exclusion Formula.
(Reference Book-2: Sec 7.1, 7.3, 8.1, 8.2)

Reference Books:

1. **Alan Tucker: Applied Combinatorics 6th Edition; Wiley India.**

Course Outcomes:

CO-1: Define Basic Counting Principles, Generating Functions.
CO-2: Formulate Recurrence relations.
CO-3: Calculate Coefficient of Generating Functions.
CO-4: Find solution of generating functions.
CO-5: Describe some Inclusion-Exclusion Formula.
CO-6: Solve linear Recurrence Relations.

SEMESTER-IV

Major Paper No: 02

Course Code: MTMAT-242 **Course Type: Theory**

Course Name: Linear Algebra

Credits: 2 **Lectures: 30**

Module-I

Unit-1: Matrices and System of Linear Equations [06 lectures]

1.1 Row echelon form of a matrix, reduced row echelon form of a matrix.

1.2 Definition of rank of a matrix using row echelon or row reduced echelon form. System of linear equations- Introduction, matrix form of linear system, Definition of row equivalent matrices.

1.3 Consistency of homogeneous and non-homogeneous system of linear Equations using rank, condition for consistency.

1.4 Solution of System of Equations: Gauss elimination and Gauss-Jordan Elimination method, examples.

Reference book 2: chapter 1: sec: 1.1, 1.2, 1.3, 1.4, 1.5(page no 17 to 66)

Reference book 4: chapter 6: sec: 6.6(page no 164 to174)

Unit-2: Vector Spaces-I [10 lectures]

2.1 Definition and Examples.

2.2 Subspaces.

2.3 Linear Dependence and Independence.

2.4 Basis of Vector Space

Reference book 1: chapter 4: sec 4.1, 4.2, 4.3(page no 95 to 103)

Module-II

Unit-3: Vector Spaces-II [08 lectures]

3.1 Dimension of a Vector Space.

3.2 Row, Column and Null Space of a matrix.

3.3 Rank and nullity.

Reference book 2: chapter 4: sec: 4.1, 4.2, 4.3, 4.5, 4.6 (page no 231 to 278)

Unit-4: Linear Transformations [6 lectures]

4.1 Definition and Examples, Properties, Equality.

4.2 Kernel and range of a linear Transformation

4.3 Rank-Nullity theorem

Reference book 3: chapter 3: sec: 3.1, 3.2, (page no 67 to 84)

Reference Books:

1. **First course in Linear algebra by P.B Bhattacharya, S K Jain, S R Nagpaul second edition.**

2. **Linear algebra and its Applications by David C. Lay Third edition**

3. **Linear algebra by Kenneth Hoffman , Ray kunze**

4. **A text book of Matrices by Shanti Narayan P.K.Mittal**

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

CO-4 : Calculate Gauss elimination and Gauss-Jordan Elimination method.

CO-5 : Solve rank and nullity of matrix

CO-6 : Describe the properties of linear transformation

SEMESTER-IV

Major Paper No: 02

Course Code: MTMAT-243 **Course Type: Theory**

Course Name: Ordinary Differential Equations.

Credits: 2 **Lectures: 30**

Module I

Unit-I Linear Differential Equations of first order with constant coefficients [6 Lectures]

3.1 Definition, Order, Degree, Solution

3.2 Formation of Differential Equation

3.3 Linear Equations

3.4 Homogeneous Equations

Unit-II Linear Differential Equations of higher order with constant coefficients [6 Lectures]

1. The auxiliary equations. Distinct roots, repeated roots, Complex roots, particular solution.
2. The operator $1/f\ (D)$ and its evaluation for the functions x^m , e^{ax}, $e^{ax}\ v$ & xv and the operator $1/(D\ 2 + a\ 2\ )$ acting on $sin\ ax$ and $cosax$

Module II

Unit-II Non-Homogeneous Differential Equations [12 Lectures]

1. Method of undetermined coefficients
2. Method of variation of parameters
3. Method of reduction of order
4. The use of a known solution to find another.

Unit-IV System of First-Order Equations [6 Lectures]

1. Introductory remarks, linear systems.
2. homogeneous linear systems with constant Coefficients, Distinct roots, repeated roots, Complex roots.

Reference Books:

1. **Differential Equations by George F. Simmons, Steven G. Krantz, Tata McGrawHill.**

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. Find solution of homogeneous linear systems with constant coefficients .

CO-4. Can identify & find solution of linear differential equations.

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

SEMESTER-IV

Major Practical Paper No: 04

Course Code: MTMAP-244 **Course Type: Practical**

Course Name: Mathematics Practical based on Linear Algebra

Credits: 2 **Practical: 12**

Practical 1: Practical on Matrices.

Practical 2: Practical on row echelon and reduced row echelon form od matrix.

Practical 3: Practical on System of Linear equations.

Practical 4: Practical on Vector Spaces-I.

Practical 5: Practical on Linear dependence and Independence.

Practical 6: Practical on Basis of Vector Space.

Practical 7: Practical on Vector Spaces-II.

Practical 8: Practical on Dimension of Vector Space.

Practical 9: Practical on Row, column and null space.

Practical 10: Practical on Rank-Nullity Theorems.

Practical 11: Practical on Linear Transformations.

Practical 12: Practical on kernel and range of Linear Transformations.

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

CO-4 : Calculate Gauss elimination and Gauss-Jordan Elimination method.

CO-5 : Solve rank and nullity of matrix

CO-6 : Describe the properties of linear transformation

SEMESTER-IV

Minor Mathematics Paper: 01

Course Code: MTMIT-241 **Course Type: Theory**

Course Name: Calculus

Credits: 2 **Lectures: 30**

Module-I

Unit 1: Numbers and functions **[07 Lectures]**

1.1 Integers, Rational numbers, real numbers
1.2 Inequalities.
1.3 Functions
1.4 Powers
(Recommended Book-1: Chapter-I)

Unit 2: Graphs and curves **[07 Lectures]**

2.1 Coordinates
2.2 Graphs
2.3 The straight line
2.4 Distance Between two points
2.5 Curves and equations
2.6 The circle
2.7. Dilations and the ellipse
2.8 The Parabola
2.9. The Hyperbola
(Recommended Book-1: Chapter-II)

Module-II

Unit 3: The Derivative **[12 Lectures]**

3.1. The Slope of a Curve
3.2. The Derivative
3.3. Limits
3.4. Powers
3.5. Sums, Products, and Quotients
3.6. The Chain Rule
3.7. Higher Derivatives
3.8. The Maximum and Minimum Theorem
3.9. Increasing and Decreasing Functions
3.10. The Mean Value Theorems
(Recommended Book-1: Chapter-III, Sec 1 to 7 and Chapter-V)

Unit 4: Integration **[04 Lectures]**

4.1 Introduction
4.2 Substitution
4.3. Integration by Parts
4.4. Trigonometric Integrals

(Recommended Book-1: Chapter-XI)

Recommended Books:

1. **First course in Calculus, Serge Lang, Springer Publication, Fifth Edition.**

Course Outcomes:

CO-1: Define matrix, determinants, functions and Limit.
CO-2: State Homogeneous system of linear equations.
CO-3: Use some condition to find consistency of homogeneous system.
CO-4: Find solution of Non-homogeneous system of linear equations.
CO-5: Describe some extensions of limit concepts.
CO-6: Apply definition to prove limit and continuity theorem.

SEMESTER-IV

Minor Mathematics Practical Paper: 01

Course Code: MTMIP-242 **Course Type: Practical**

Course Name: Practical on Calculus

Credits: 2 **Practical: 12**

Practical No. 01: Practical on Numbers.
Practical No. 02: Practical on Functions.
Practical No. 03: Practical on Graphs.
Practical No. 04: Practical on Curves.
Practical No. 05: Practical on Derivatives.
Practical No. 06: Practical on Chain Rule.
Practical No. 07: Practical on Higher Derivatives.
Practical No. 08: Practical on the Maximum and Minimum Theorem.
Practical No. 09: Practical on Increasing and Decreasing Functions.
Practical No. 10: Practical on the Mean Value Theorems.
Practical No. 11: Practical on Integration.
Practical No. 12: Practical on Trigonometric Integration.

Course Outcomes:

CO-1: Define matrix, determinants, functions and Limit.
CO-2: State Homogeneous system of linear equations.
CO-3: Use some condition to find consistency of homogeneous system.
CO-4: Find solution of Non-homogeneous system of linear equations.
CO-5: Describe some extensions of limit concepts.
CO-6: Apply definition to prove limit and continuity theorem.

SEMESTER-IV

Skill Enhancement Paper No.: 01

Course Code: MTSET-241 **Course Type: Theory**

Course Name: Computational Geometry

Credits: 2 **Lectures: 30**

Module -I

Unit 1: Two Dimensional Transformations [12 Lectures]

1.1 Representation of points.
1.2 Transformations and matrices.
1.3 Transformation of points.
1.4 Transformation of straight lines
1.5 Midpoint Transformation
1.6 Transformation of parallel lines
1.7 Transformation of intersecting lines
1.8 Transformation: rotations, reflections, scaling, shearing.
1.9 Combined transformations.
1.10 Transformation of a unit square.
1.11 Solid body transformations.
1.12 Translations and homogeneous coordinates.
1.13 Rotation about an arbitrary point.
1.14 Reflection through an arbitrary line.

Unit 2: Three dimensional transformation [6 lectures]

2.1 Introduction.
2.2 Three dimensional – Scaling, shearing, rotation, reflection, translation. 2.3 Multiple transformations.
2.3 Rotation about – an axis parallel to coordinate axes, an arbitrary line 2.5 Reflection through – coordinate planes, planes parallel to coordinate planes , an arbitrary plane

Module – II

Unit 3: Projection [6 lectures]

3.1 Orthographic projections.
3.2 Axonometric projections.
3.3 Oblique projections
3.4 Single point perspective projection

Unit 4: Plane and Space Curves **[6 lectures]**

4.1 Introduction.
4.2 Curve representation.
4.3 Parametric curves.
4.4 Parametric representation of a circle and generation of circle.
4.5 Bezier Curves – Introduction, definition, properties (without proof), Curve fitting (up to n = 3), equation of the curve in matrix form (upto n = 3)

Recommended Books:

1. D. F. Rogers, J. A. Adams, Mathematical elements for Computer graphics, Mc Graw Hill Intnl Edition.

Unit 1: Chapter 2: Sec. 2-1 to 2.17
Unit 2: Chapter 3: Sec. 3.1 to 3.10,
Unit 3: Chapter 3: Sec. 3.12 to 3.14
Unit 4: Chapter 4: Sec. 4.1, 4.2, 4.5, Chapter 5: Sec. 5.1, 5.8

Reference books:

1. Computer Graphics with OpenGL, Donald Hearn, M. Pauline Baker, Warren Carithers, Pearson (4th Edition)
2. Schaum Series, Computer Graphics.

Course Outcomes:

CO-1: Define the two dimensional homogenous co-ordinates.

CO-2: State the different transformations Scaling, Rotation, Reflection, Shearing.

CO-3: Derive the condition for three dimensional homogenous co ordinates

CO-4: Find the equation Orthographic, Axonometric projection.

CO-5: Solve examples on dimetric and trimetric projection

CO-6: Find equations of Beizeir Curves.

SEMESTER-III

General Elective Paper No.: 02

Course Code: MTGEP-241 **Course Type: Practical**

Course Name: Practical on Basic Algebra

Credits: 2 **Practical: 12**

Practical No. 1: Practical on Matrices
Practical No. 2: Practical on Determinants
Practical No. 3: Practical on Adjoint and inverse of matrix
Practical No. 4: Practical on Homogeneous system of linear equation
Practical No. 5: Practical on Consistency of homogeneous system of linear equations
Practical No. 6: Practical on Solution of Nonhomogeneous system of linear equations
Practical No. 7: Practical on Functions
Practical No. 8: Practical on Classification of functions with examples
Practical No. 9: Practical on Problems on composition of functions
Practical No. 10: Practical on Problems on Inverse of a functions
Practical No. 11: Practical on Limits
Practical No. 12: Practical on Examples based on theorems of limits

Course Outcomes:

CO-1: Define matrix, determinants, functions and Limit.
CO-2: State Homogeneous system of linear equations.
CO-3: Use some condition to find consistency of homogeneous system.
CO-4: Find solution of Non-homogeneous system of linear equations.
CO-5: Describe some extensions of limit concepts.
CO-6: Apply definition to prove limit and continuity theorem.