HSNC UNIVERSITY, MUMBAI

Board of Studies

in

Faculties of Science & Technology

Board of Studies in Mathematics

1. **Name of Chairperson**

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

Name of Co-Chairperson

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

2. **Two to five teachers each having minimum five years teaching experience amongst the full-time teachers of the Departments, in the relevant subject.**
   a.) Dr. Pankit Gandhi, MSc (Mathematics), M Phil, Ph.D., LL.B., Associate Professor, K. C. College, Ph: 8169381936 Email id: pankit.gandhi@kccollege.edu
   b.) Mrs. Suman Gupta,MSc Operations Research,Assistant Professor,H. R. College,Ph: 9869003141; Email id: suman11262@gmail.com
   c.) Mrs. Vijayalaxmi Suvarna ,M Sc Mathematics, M.Phil ,Assistant Professor,H. R. College, Ph: 9987395783; Email id: vijayalaxmi_suvarna@rediffmail.com
   d.) Mrs. Mrunal Hardikar ,M Sc Mathematic, Assistant Professor, K. C. College, Ph: 9653227252; Email id: mrunal.hardikar@kccollege

3. **One Professor / Associate Professor from other Universities or professor / Associate Professor from colleges managed by Parent Body; nominated by Parent Body;-**
   a.) Dr Sushil Kulkarni ,Ph.D. Matthematics,Associate Professor, Head, Department of Mathematics and Controller of Examinations, Jai Hind (Autonomous) College., Ph No 9870126536; Email id: sushil.kulkarni@jaihindcollege.edu.in

4. **External experts from Industry / Research / eminent scholar in the field relevant to the subject nominated by the Parent Body**;
    a.) Dr Ajit Kumar , Ph.D. Mathematics,Associate Professor and Head, Department of Mathematics, Institute of Chemical Technology, Mumbai,Ph No. 99690 31202; E Mail id ajit72@gmail.com
    b.) Mrs. Jayashree Shetty, Associate Professor, KPB Hinduja College, Mumbai,Ph: 9821690011; Email Id: shettyju@live.in
    c.) Dr. Amiya Ranjan Bhowmick, Ph.D. Applied Mathematics and Statistics; Assistant Professor, Institute of Chemical Technology, Mumbai, Ph no: 08334835300/7738101583; amiyaiitb@gmail.com/ar.bhowmick@ictmumbai.edu.in
    d.) Mr. Prashant Shukla,MSc statistics, Masters in Financial Management JBIMS; Chief Investment Officer, Aston Capital Advisor Pvt Ltd,Partner at HBD Consulting LLP; Ph no:9821470975; Email id: sprash@rediffmail.com
    e.) Mr. Nikunj Sharma ,Zonal Head, Tata Portfolio JLL,Ph: 9920475159; Email id: nikunj.sharma@ap.jll.com
    f.) Mr. Kaushal Shah,M.Com, PGDBA(Finance),Senior Manager, Treasury Reliance Power, Ph no: 9320105703; Email id: krushalshah78@gmail.com
    g.) Mr. Ravi Vyas ,Founder S.MONK School of Actuaries,Ph: 8169914289; Email id: ravivyas1993@gmail.com

5. **Top rankers of the Final Year Graduate and Final Year Post Graduate examination of previous year of the concerned subject as invitee members for discussions on framing or revision of syllabus of that subject or group of subjects for one year.**
    a.) Divya Srivastav, MSc. Statistics MIT-WPU, Pune., BSc. Statistics, K.C. College, Mumbai. Email: divyasrivastav20@gmail.com; Phone no. 8879240305
    b.) Ms. Gunjan Shinde, B Sc, Mathematics,Currently pursuing online Degree in data Science and Programming from IIT ,Madras

Part –I

Outline of Choice Based Credit System as outlined by University Grants Commission:

R. **: The Definitions of The Key Terms Used in The Choice Based Credit System And Grading System Introduced From TheAcademicYear2020-2021AreAs Under:**

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. **Elective Course:** Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

   2.1 **Discipline Specific Elective (DSE) Course**: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

   2.2 **Dissertation/Project:** An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

   2.3 **Generic Elective (GE) Course:** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective. P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. **Choice Base Credit System:** CBCS allows students to choose inter- disciplinary, intra-disciplinary courses, skill-oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students.
4. **Honors Program:** To enhance employability and entrepreneurship abilities among the learners, through aligning Inter Disciplinary / Intra Disciplinary courses with Degree Program. Honours Program will have 40 additional credits to be undertaken by the learner across three years essentially in Inter / Intra Disciplinary course.

A learner who joins Regular Undergraduate Program will have to opt for Honours Program in the first year of the Program. However, the credits for honours, though divided across three years can be completed within three years to become eligible for award of honours Degree.

5. **Program:** A Program is a set of course that are linked together in an academically meaningful way and generally ends with the award of a Degree Certificate depending on the level of knowledge attained and the total duration of study, B.Sc. Programs.

6. **Course:** A 'course' is essentially a constituent of a 'program' and may be conceived of as a composite of several learning topics taken from a certain knowledge domain, at a certain level. All the learning topics included in a course must necessarily have academic coherence, i.e. there

must be a common thread linking the various components of a course. A number of linked courses considered together are in practice, a 'program'.

7. **Bridge Course:** Bridge course is visualized as Pre semester preparation by the learner before commencement of regular lectures. For each semester the topics, whose knowledge is considered as essential for effective and seamless learning of topics of the Semester, will be specified. The Bridge Course can be conducted in online mode. The Online content can be created for the Bridge Course Topics.

8. **Module and Unit:** A course which is generally an independent entity having its own separate identity, is also often referred to as a 'Module' in today's parlance, especially when we refer to a 'modular curricular structure'. A module may be studied in conjunction with other learning modules or studied independently. A topic within a course is treated as a Unit. Each course should have exactly 3 Units.

9. **Self-Learning: 20% of the topics will be marked for Self-Learning.** Topics for Self-Learning are to be learned independently by the student, in a time- bound manner, using online and offline resources including online lectures, videos, library, discussion forums, fieldwork, internships etc.

Evaluative sessions (physical/online), equivalent to the credit allocation of the Self Learning topics, shall be conducted, preferably, every week for each course. Learners are to be evaluated real time during evaluative sessions. The purpose of evaluative sessions is to assess the level of the students' learning achieved in the topics are marked for Self-Learning.

The teacher's role in these evaluative sessions will be that of a Moderator and Mentor, who will guide and navigate the discussions in the sessions, and offer concluding remarks, with proper reasoning on the aspects which may have been missed by the students, in the course of the Self-Learning process.

The modes to evaluate self-learning can be a combination of the various methods such as written reports, handouts with gaps and MCQs, objective tests, case studies and Peer learning. Groups can be formed to present self- learning topics to peer groups, followed by Question-and-Answer sessions and open discussion. The marking scheme for Self-Learning will be defined under Examination and Teaching.

The topics stipulated for self-learning can be increased or reduced as per the recommendations of the Board of Studies and Academic Council from time to time. All decisions regarding evaluation need to be taken and communicated to the stakeholders preferably before the commencement of a semester. Some exceptions may be made in exigencies, like the current situation arising from the lockdown, but such adhoc decisions are to be kept to the minimum possible.

10. **Credit Point:** Credit Point refers to the 'Workload' of a learner and is an index of the number of learning hours deemed for a certain segment of learning. These learning hours may include a variety of learning activities like reading, reflecting, discussing, attending lectures / counseling sessions, watching especially prepared videos, writing assignments, preparing for examinations, etc. Credits assigned for a single course always pay attention to how many hours it would take for a learner to complete a single course successfully. A single course should have, by and large a course may be assigned anywhere between 2 to 8 credit points wherein 1 credit is construed as corresponding to approximately 30 to 40 learning hours.

11. **Credit Completion and Credit Accumulation:** Credit completion or Credit acquisition shall be considered to take place after the learner has successfully cleared all the evaluation criteria with respect to a single course. Thus, a learner who successfully completes a 4 CP (Credit Point) course may be considered to have collected or acquired 4 credits. learner level of performance above the minimum prescribed level (viz. grades / marks obtained) has no bearing on the number of credits collected or acquired. A learner keeps on adding more and more credits as he completes successfully more and more courses. Thus, the learner 'accumulates' course wise credits.

12. **Credit Bank:** A Credit Bank in simple terms refers to stored and dynamically updated information regarding the number of Credits obtained by any given learner along with details regarding the course/s for which Credit has been given, the course-level, nature, etc. In addition, all the information regarding the number of Credits transferred to different programs or credit exemptions given may also be stored with the individual's history.

13. **Credit Transfer:** (performance transfer) When a learner successfully completes a program, he/she is allowed to transfer his/her past performance to another academic program having some common courses and Performance transfer is said to have taken place.

14. **Course Exemption:** Occasionally, when two academic programs offered by a single university or by more than one university, may have some common or equivalent course-content, the learner who has already completed one of these academic programs is allowed to skip these 'equivalent' courses while registering for the new program. The Learner is 'exempted' from 'relearning' the common or equivalent content area and from re-appearing for the concerned examinations. It is thus taken for granted that the learner has already collected in the past the credits corresponding to the exempted courses.

Part-II

O*** The fees for transfer of credits or performance will be based on number of credits that a learner has to complete for award of the degree.**

The Scheme of Teaching and Examination:

The performance of the learners shall be evaluated in two components: Internal Assessment with 40% marks by way of continuous evaluation and by Semester End Examination with 60% marks by conducting the theory examination.

INTERNAL ASSESSMENT: - It is defined as the assessment of the learners on the basis of continuous evaluation as envisaged in the credit-based system by way of participation of learners in various academic and correlated activities in the given semester of the programme.

A). Internal Assessment– 40% 40 marks

Practical's (internal Components of the Practical Course

1. For Theory Courses

Sr. No.	Particulars	Marks
1	**ONE** class test/online examination to be conducted in the given semester	15 Marks
2	One assignment based on curriculum (to be assessed by the teacher Concerned	10 Marks
3	Self-Learning Evaluation	10 Marks

4	Active participation in routine class instructional deliveries	05 Marks

2. For Courses with Practicals

Each practical course can be conducted out of 50 marks with 20 marks for internal and 30 marks for external

Practical's (Internal component of the Practical Course)

Sr. No	Evaluation type	Marks
1	Two Best Practicals /Assignments/Presentation /Preparation of models/ Exhibits **Or** One Assignment/ project with class presentation to be assessed by teacher concerned	10
2	Journal	05
3	Viva	05

The semester end examination (external component) of 60 % for each course will be as follows:

i) **Duration** – **2 Hours** ii) **Theory Question Paper**

Pattern: -

1. There shall be four questions each of 15 marks. On each unit there will be one question and the fourth one will be based on entire syllabus.
2. All questions shall be compulsory with internal choice within the questions. (Each question will be of 20 to 23 marks with options.)
3. Question may be subdivided into sub-questions a, b, c… and the allocation of marks depend on the weightage of the topic.

The marks will be given for all examinations and they will be converted into grade (quality) points. The semester-end, final grade sheets and transcripts will have only credits, grades, grade points, SGPA and CGPA.

3. **Project and Assignment:**

Project or Assignment, which can in the following forms

- Case Studies
- Videos
- Blogs
- Research paper (Presented in Seminar/Conference)
- Field Visit Report
- Presentations related to the subject (Moot Court, Youth Parliament, etc.)
- Internships (Exposition of theory into practice)
- Open Book Test
- any other innovative methods adopted with the prior approval of Director Board of Examination and Evaluation.

4. **Self-Learning Evaluation**

- **20% OF THE TOPICS OF CURRICULUM ARE LEARNED BY THE STUDENT THROUGH SELF LEARNING USING ONLINE / OFFLINE ACADEMIC RESOURSE SPECIFIED IN THE CURRICULUM.**

- **HENCE 20% OF THE LECTURES SHALL BE ALLOCATED FOR EVALUATION OF STUDENTS ON SELF LEARNING TOPICS**

- The identified topics in the syllabus shall be learnt independently by the students in a time bound manner preferably from online resources. Evaluative sessions shall be conducted by the teachers and will carry 10 Marks.

- CLUB The self-learning topics into 3-4 GROUPS OF TOPICS ONLY FOR EVALUATION.

- **PRESCRIBE TIME DURATION (IN DAYS) FOR COMPLETION OF EACH GROUP OF TOPIC AND EARMARK SELF LEARNING EVALUATION LECTURES IN THE TIMETABLE. HENCE EACH GROUP OF TOPIC CAN BE ASSIGNED 3 REGULAR LECTURES FOR THIS EVALUATION FOR ENTIRE CLASS**

  3 Sub Topics
  Each evaluative session shall carry 3 Marks (3 x 3 Units = 9 Marks). Students who participate in all evaluative sessions shall be awarded 1 additional Mark.
  4 Sub Topics
  Each evaluative session shall carry 2.5 Marks (2.5 x 4 Units = 10 Marks)

- **EVALUATION OF SELF LEARNING TOPICS CAN COMMENCE IN REGULAR LECTURES ASSIGNED FOR SELF LEARNING EVALUATION IN THE TIMETABLE**

3 Evaluative sessions
Each evaluative session shall carry 3 Marks (3 x 3 = 9 Marks). Students who participate in all evaluative sessions shall be awarded 1 additional Mark
4 **Evaluative sessions**
Each evaluative session shall carry 2.5 Marks (2.5 x 4 = 10 Marks).

Methods for Evaluation of Self-learning topics:

- Seminars/presentation (PPT or pdf), followed by Q&A – Objective questions /Quiz / Framing of MCQ questions.
- Debates
- Group discussion
- You-Tube videos (Marks shall be based on the quality and viewership)
- Improvisation of videos
- Role Play followed by question-answers
-

TEACHERS CAN FRAME OTHER METHODS OF EVALUATION ALSO PROVIDED THAT THE METHOD, DULY APPROVED BY THE COLLEGE EXAMINATION COMMITTEE, IS NOTIFIED TO THE STUDENTS AT LEAST 7 DAYS BEFORE THE COMMENCEMENT OF THE EVALUATION SESSION AND IS FORWARDED FOR INFORMATION AND NECESSARY ACTION AT LEAT 3 DAYS BEFORE THE COMMENCEMENT OF THE EVALUATION SESSION

- Viva Voce
- Any other innovative method

SEMESTER END EXAMINATION: - It is defined as the examination of the learners on the basis of performance in the semester end theory / written examinations.

B. Semester End Examination-60 % ***60 Marks***

1) Duration – These examinations shall be of 2 Hours duration.
2) Question Paper Pattern: -
   i. There shall be four questions each of 15 marks.
   ii. All questions shall be compulsory with internal choice within the questions.
   iii. Question may be sub-divided into sub-questions a, b, c, d & e only and the allocation of marks depends on the weightage of the topic.

THE MARKS OF THE INTERNAL ASSESSMENT SHOULD NOT BE DISCLOSED TO THE STUDENTS TILL THE RESULTS OF THE CORRESPONDING SEMESTER IS DECLARED.

HSNC University Mumbai

(2022-2023)

Ordinances and Regulations

With Respect to

Choice Based Credit System

(CBCS)

For the Programmes Under

The Faculty of Science and Technology

For the Course

MATHEMATICS

Semester-V and Semester -VI

With effect from the Academic year 2022-2023

Part 1-

Preamble

- The subject of Pure Mathematics is one of the most original creation of the human mind. It is a contemporary subject whose concepts and methodologies are being used by Physicists, Statisticians, Computer Scientists, Chemists, Biologists, Economists and financial advisors to name a few.
- This proposed curriculum is drafted with a view to create an option for B.Sc. in both Pure and Applied Mathematics.
- There are two courses of Mathematics for Science students at the F.Y.B.Sc. level in Semesters I as well as II and at S.Y.B.Sc. level, three courses each in semester III and IV,There are three Courses in Core Subjects with practical sessions of two lectures each for all the three core subjects .There will be no practical session for the elective paper .And two practical sessions of two lectures for the applied component.
- The assignments, projects which will be part of internal assessment aims to improve the problem-solving ability of the learners and also their ability to do teamwork. It will help the learner to get an in depth understanding of the topic. The presentations which will be part of the internal assessment will improve presentation and interpersonal communication skills.
- In addition to traditional problem-solving sessions, there will be few hands-on training sessions using Computer Algebra System (CAS)like Sage Math, GeoGebra and also using Python programming.
- The interested students will be taught Latex so that they can submit there project work in Latex.

1. Course Objectives:

- Imparting knowledge to the students on very important basic concepts of Pure Mathematics in Calculus and Discrete Mathematics which are applied and needed in various branches of science and humanities.
- Giving a broad overview and introduction to the nature of the subject and develop Mathematical tools for continuing further study in various other disciplines.

2. Process adopted for curriculum Designing:

- After several rounds of discussion, at the departmental level, the members of the Department of Mathematics drafted the syllabus. The draft syllabus was shown to Industry Partners, Academic Partners and Research Institute Partners, through meetings and mails They suggested some changes. These changes were incorporated.

3. Salient features, how it has been made more relevant.

- The subject of Mathematics is the blend of Pure Mathematics and applied mathematics. Apart from the theorems and proofs which gives them better understanding of the basic concepts in mathematics, we have added practical sessions with CAS like Sage Math, Geogebra, Python,which will teach them how to use mathematics as a tool in real life problems without doing rigorous theory and tedious calculations.
- The course would give the learners option to develop skills in areas which have direct relevance to employability in industry, finance, banking, and computer software designing apart from research in mathematics and teaching profession.

4. Learning Outcomes:

- The learner's understanding and problem-solving skills on the basic mathematical concepts of Calculus and Discrete Mathematics will get enhanced and they will start developing affinity for the subject of Mathematics.

- The learner's mathematical abilities will be enhanced due to in depth study of Logic and they will gradually be able to use appropriate mathematical language: notations, symbols, terminology, in both oral and written explanations.
- Since the theory of Mathematics has been applied using CAS techniques and numerical methods, the Learner's ability to synthesize the acquired knowledge, understanding and experience for a better and improved comprehension of the real-life problems will enhance.
- The learner will be able to mathematically formulate problems arising in the other subjects like Physics, Statistics, Operations Research, Law, Economics etc. will enhance and also will be able to solve these problems applying the mathematical tools learnt.

- The introduction of the self-learning of certain topics will enhance the learners' ability to understand, apply and experiment, which can give them the ability to think differently.

- The learner will be ready with the knowledge of computer software which will have the job opportunities.

- The learner will be introduced to the important branches of Modern Mathematics Like Calculus ,Real Analysis, Complex Analysis ,Modern Algebra ,Metric Space ,Number theory and it's Applications .

- The topic of Financial Mathematics as an applied Component will give an apportunity to learner know the application of Mathematics in Finance.

5. Input from stakeholders:

- As per the suggestions given by the stake holders following changes were made in the draft syllabus.
- The Unit I: Differential Equations in Semester II (Calculus II) in the draft syllabus has been shifted to Semester I (Calculus I) and Limits and Continuity has been shifted to Semester II (Calculus II).
- Existence of square root of a non-square positive integer in Unit II SEM I has been added.
- In Semester I (Discrete Mathematics I) the concept of Family of set has been added.
- The Semester II, Course II (Linear Algebra I) has been replaced by a Course on Discrete Mathematics (Discrete Mathematics II).
- We have adopted the same Credit System as of the present T Y B Sc in Mathematics at Mumbai University.

Part 2. The Scheme of Teaching and Examination

Semester – V

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (Mathematics)			US-TMA-501, US-TMA-502, US-TMA-503 US-TMA- P-5	
2	Elective Course	Discipline Specific Elective (DSE) Course		US-TMA-504	
		2.1	Interdisciplinary Specific Elective (IDSE) Course	-	
		2.2	Dissertation/Project	-	
		2.3	Generic Elective (GE) Course	-	
3	Ability Enhancement Courses (AEC)			-	
	Skill Enhancement Courses (SEC)			-	

First year Semester-I Internal and External Assessment Detail Scheme:

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme				Total Marks
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	US-TMA-501	Calculus And Analysis	3	20 % *	3	0	0	2.5	10	20	10	60	100
2	US-TMA-502	Algebra I	3	20 % *	3	0	0	2.5	10	20	10	60	100
3	US-TMA-503	Topology of Metric Spaces I	3	20 % *	3	0	0	2.5	10	20	10	60	100
4	US-TMA-503	Number Theory-I	3	20 % *	3	0	0	2.5	10	20	10	60	100
5	US-TMA-P-5	Practical Sessions Based on US-TMA-501, US-TMA-502 and US-TMA-503 with implementation	3	-	0	0	3	3				150 (90+60)	150

		using GeoGebra and Sage Math											
6		Project	2					3					100
	Total / Credit		16						Total Marks				650

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

Semester – I Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours/Lectures	Total No. of hours/lectures	Credit	Tot al Marks
1	US-TMA-501	I	Sequences And Series of Functions	15	45 L	2.5	100 (60+40)
		II	Multiple integrals	15			
		III	Integration in Vector Fields	15			
2	US-TMA-502	I	An Introduction to Groups	15	45L	2.5	100 (60+40)
		II	Subgroups, Cosets and permutation groups	15			
		III	Group Isomorphism	15			
3	US-TMA-503	I	Metric Spaces	15	45L	2.5	100 (60+40)
		II	Sequences, closed sets, limit Points	15			
		III	Continuity in Metric Space	15			
4	US-TMA-504	I	Congruences and Factorization	15	45L	2.5	100 (60+40)
		II	Diophantine equations and their solutions	15			
		III	Primitive Roots and Cryptography	15			
5	US-TMA-P-5	I	Practical Sessions Based on US-TMA-501, US-TMA-502 and US-TMA-503 with implementation using GeoGebra and Sage Math	3	30x3= 90L lectures per batch	3	150 (90+60)
			TOTAL			13	550

- **Lecture Duration – 45 Minutes = 0 .75 Hours. (45 Lectures equivalent to 33.75 hours)**
- **One Credit =16.87 hours equivalent to 17 Hours**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination, PA-Project Assessment, AT- Attendance

Part3: Detail Scheme Theory
T.Y.B.SC. MATHEMATICS SYLLABUS
(SEMESTER BASED CREDIT AND GRADING SYSTEM)
TO BE IMPLEMENTED FROM THE ACADEMIC YEAR 2022-2023

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

Course I: **Course Code: US-TMA-501**
Title of course: **Calculus and Analysis** **Total credits: 2.5**
Objective:
The aim of this Course is to cover some basic topics in Calculus And in Real Analysis ,ahead of the Topics which the learner has Studied in the previous four semesters.

Unit	Content	No. of Lectures
1	**1 Sequences and Series of Functions** **1.1** Sequence of real valued functions: Pointwise and Uniform Convergence of Sequence of real valued functions, relation between Pointwise and Uniform Convergence, Consequences of Uniform Convergence. **1.2** Series of functions: convergence of a series of functions, Weierstrass M-test. **1.3** Convergence and Uniform convergence of series of Functions: Properties of uniform convergence, Continuity of the uniform limit of a sequence of continuous function, conditions under which integral and the derivative of sequence of functions converge to the integral and derivative of uniform limit on a closed and bounded interval, examples. Consequences of these properties for series of functions, term by term differentiation and integration, lim inf x_n, lim sup x_n for a sequence (x_n) **1.4** Power series in R: radius of convergence, region (interval) of convergence, uniform convergence, term by-term differentiation and integration of power series. Uniqueness of series representation, functions represented by power series, classical functions defined by power series such as exponential, cosine and sine functions, the basic properties of these functions.	**15**
2	**2 Multiple integrals** **2.1** Review of functions of two and three variables, partial derivatives and gradient of two or three variables, Double integrals, double integrals over rectangles, Properties of double integrals, Double integrals over bounded nonrectangular regions, Double integrals as volumes, Fubini's Theorem (without proof) **2.2** Applications of Double integrals: Average value, Areas, Moments, Center of Mass, Double integrals in polar form. Changing Cartesian Integrals into Polar Integrals. **2.3** Triple integrals in rectangular coordinates, Applications of Triple integrals: Average values, Mass, Moments in three Dimensions, Parallel axis Theorem., Triple integrals in Spherical and Cylindrical coordinates. Substitutions in double and triple Integrals.	**15**
3	**3. Integration in Vector Fields**	**15**

	3.1 Line Integrals, Definition, Evaluation for smooth curves. Mass and moments for coils, springs, thin rods. , Vector fields, Work, Circulation ,flux Gradient fields, Work done by a force over a curve in space, Evaluation of work integrals, Flow integrals and circulation around a curve, Flux across a plane curve. 3.2 Path independence, Potential Field, line integrals in. Conservative fields, potential function, The Fundamental theorems of line integrals (without proof). 3.3 Green's Theorem in the plane (without proof), Flux density or divergence of vector field, the curl or circulation Density at a point, Evaluation of line integrals using Green's Theorem, Evaluation of line integrals using Green's Theorem 3.4 Surface area, Surface Integral, Strokes's Theorem	

Reference Books:

1. A Basic Course in Real Analysis, Ajit kumar, S. Kumaresan, CRC Press, 2014. (Chapter 5(5.1),6for unit1
2. Introduction to Real Analysis -R. G. Bartle- D. R. Sherbert, John Wilely & Sons, 1994, Chapter8: 8.1,8.2,8.3,8.4,9.4(Unit1)
3. Calculus and Analytic Geometry, G.B. Thomas and R. L. Finney, Ninth Edition, Addison-Wesle Chapter 13, Sections 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, (unit2)Chapter 14: 14.1, 14.2, 14.3, 14.4. 14.5(Unit 3)
4. Calculus T.M. Apostol, Volume I, Wiley & Sons (Asia) Pte, Ltd.
5. Calculus James Stewart, Third Edition, Brooks/ Cole Publishing Company,

Self-Learning topics (Unit wise)

Unit	Topics
2.1	Review of functions of two and three variables, partial derivatives and gradient of two or three variables
2.2	Double integrals in polar form. Changing Cartesian Integrals into Polar Integrals.
2.3	Applications of Triple integrals: Average values, Mass, Moments in three Dimensions, Triple integrals in Spherical and Cylindrical coordinates

Online Resource

https://archive.nptel.ac.in/courses/111/107/111107108/# Multivariable Calculus by PROF. S. K. GUPTA & PROF. SANJEEV KUMAR Department of Mathematics IIT Roorkee (lecture 20 onwards)

Course II: **Course Code: US-TMA-502** **Credits:2.5**

Modern Algebra – I (Group Theory)
Objective: The objective of this course is to introduce the learner to the topic of Group theory in this Basic Course in Modern Algebra

Unit	Content	No. of Lectures
1	**An Introduction to Groups** 1.1. Definition and properties of Groups with examples. 1.2. Abelian groups, finite and infinite groups. 1.3. Order of an element.	**15**
2	**Subgroups Cosets and Permutation Groups** 2.1. Subgroups. 2.2 Cyclic groups. 2.3. Group Cosets, Lagrange's theorem 2.4. Permutation Groups	**15**
3	**Group Isomorphism** 3.1. Normal Subgroups 3.2. Quotient groups. 3.3. Homomorphism and isomorphism of Groups 3.4. Cayley's Theorem for finite groups.	**15**

Reference Books:
1. I. N. Herstein, Topics in Algebra, Wiley, 1990
2. P. B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, Second Ed., Foundation Books, New
Delhi, 1995.
3. J. B. Fraleigh, A. First Course in Abstract Algebra, Third Ed., Narosa, New Delhi, 1990.
4. N. S. Gopalakrishnan, University Algebra, Second Ed., New Age International, New Delhi, 1986.
5. Ajit Kumar and Vikas Bist, Group Theory: An expedition with SageMath, Narosa.

Self-Learning topics (Unit wise)

Unit	Topics
1.1	properties of Groups with examples.
2.1	Subgroups.
2.4	Permutation Groups

Online Resource

https://archive.nptel.ac.in/courses/111/106/111106113/
(link for NPTEL lecture for Abstract Group Theory, PROF. KRISHNA HANUMANTHU Department of Mathematics Chennai Mathematical Institute)

Course III: **Course Code: US-TMA-503** **Credits:2.5**

Topology of Metric Spaces – I

Objectives:

1. Learner will be introduced to the basic concepts of Topology of Metric Spaces , the important branch of Modern Mathematics that a learner should study at undergraduate level.

Unit	Content	No. of Lectures
1	**Metric Spaces** **1.1** Definition and Examples of metric space. **1.2** Normed linear spaces: Inner Product Space,Definition of the the distance (metric) induced by the norm, translation invariance of the metric induced by the norm. Definition Examples of normed linear spaces including 1. $\mathbb{R}^n$ with sum norm $\|\ \|_1$, the Euclidean norm $\|\ \|_2$, and the sup norm $\|\ \|_\infty$. 2. $\square$ [a, b], the space of continuous real valued functions on [a, b] with norms $\|\ \|_1$, $\|\ \|_2$, and $\|\ \|_\infty$, where $\|f\|_1 = \int_{\square}^{\square} \|\square(\square)\|\square\square$, $\|f\|_2 = (\int_{\square}^{\square} \|\square(\square)\|^2\square\square)^{1/2}$, $\|f\|_\infty = \sup\{\|f(t)\| : t \in [a, b]\}$. **1.3** Open balls and Open Sets of a metric space:Examples ,Properties. The intersection and the union of open subsets of a metric space. Product Metric,Young's,Hölder's and Minkowski Inequalities Interior of a subset of a Metric space. Hausdorff property of a metric space, Hausdroff Space. Subspaces of a Metric space. spaces. Equivalent metrics. Distance of a point from a set, distance between two sets, diameter of a set in a metric space.	**15**
2	**2. Closed sets, Limit Points, Sequences in a Metric space** 2.1 Closed set in a metric space, limit point of a set, isolated point. Closure Property, Closed balls, Examples 1.2 Closure of a subset E of a metric space and it's properties Boundary of a set in a metric space 1.3 Sequences in a metric space: limit of a sequence, convergent sequences, subsequence of a sequence Cauchy sequences in a metric space, examples, Complete metric spaces.	**15**
3	**Continuity in Metric Space** 3.1. $\in$ - δ definition of continuity at a point for a function from one metric space to another. Characterization of continuity at a point in terms of sequences, open sets. 32 Continuity of a function on a metric space. Characterization of continuity of a function in terms of inverse image of open sets and closed sets. Algebra of continuous real valued functions. 33 Uniform continuity of a function defined on a metric space.	**15**

Recommended Textbooks:

1. S. Kumaresan, Topology of Metric spaces, Narosa.
2. P. K. Jain, K. Ahmed, Metric Spaces, Narosa, New Delhi, 1996.
3. W. Rudin, Principles of Mathematical Analysis, Tata McGraw- Hill Education in 2013
4. E. T. Copson, Metric Spaces, Universal Book Stall, New Delhi, 1996.
5. T. Apostol, Mathematical Analysis, Narosa.

6. R. R. Goldberg, Methods of Real Analysis.
7. D. Somasundaram, B. Choudhary, A first Course in Mathematical Analysis.

Self-Learning topics (Unit wise)

Unit	Topics
1.2	Examples of normed linear spaces including 1. $\mathbb{R}^n$ with sum norm $\|\|_1$, the Euclidean norm $\|\|_2$, and the sup norm $\|\|_\infty$. 2. C [a, b], the space of continuous real valued functions on [a, b] with norms $\|\|_1$, $\|\|_2$, and $\|\|_\infty$, where $\|f\|_1 = \int_a^b \|f(t)\|\,dt$, $\|f\|_2 = \left(\int_a^b \|f(t)\|^2 dt\right)^{1/2}$, $\|f\|_\infty = \sup\{\|f(t)\| : t \in [a, b]\}$. Product Metric, Young's, Hölder's and Minkowski Inequalities
1.3	The intersection and the union of open subsets of a metric space .
3.2	Algebra of continuous real valued functions.

Online Resource

1. https://4dspace.mtts.org.in/vl by S.Kumaresan

2. https://archive.nptel.ac.in/courses/111/101/111101158/#watch
AN INTRODUCTION TO POINT-SET-TOPOLOGY PART-I,By PROF. ANANT R SHASTRI Department of Mathematics IIT Bombay,
2. https://archive.nptel.ac.in/courses/111/106/111106054/

Course IV: **Course Code: US-TMA-504** **Credits: 2.5**
Number Theory and its application I (Elective A)
Objectives:

2. Learner will be introduced to the basic concepts of number theory.
3. Learners will appreciate the one of the oldest branches of mathematics by studying its applications to the latest cryptography techniques.

Unit	Content	No. of Lectures
1	**1. Congruences and Factorization** **1.1** Review of divisibility, Primes, The fundamental theorem of arithmetic. **1.2** Congruences: Definition and elementary properties, Complete residue system modulo m; Reduced residue system modulo m. **1.3** Euler's function, and its properties, Fermat's little Theorem, Euler's generalization of Fermat's little Theorem, Wilson's theorem. **1.4** Linear congruence, The Chinese remainder Theorem. **1.5** Congruences of higher degree, The Fermat-Kraitchik Factorization Method.	**15**
2	**2. Diophantine equations and their solutions** 2.1. The linear equations $ax + by = c$. The equations $x^2 + y^2$ where p is prime. 2.2. Pythagorean triplets, primitive solutions 2.3. The equations $x^4 + y^4 = z^2$ and $x^4 + y^4 = z^4$ have no solutions with $xyz \neq 0$. 2.4. Every positive integer can be expressed as sum of four squares	**15**

3	**3. Primitive Roots and Cryptography** 3.1. Order of an integer and Primitive Roots. 3.2. Basic notions such as encryption (enciphering) and decryption (deciphering), Crypto-systems, symmetric key cryptography, simple examples such as shift cipher, Affine cipher, Hill's cipher, Vigenère cipher. 3.3. Concept of Public Key Crypto system; RSA Algorithm. An application of Primitive Roots to Cryptography.	**15**

Self-Learning topics (Unit wise)

Unit	SLE Topics
1	**1.1** Review of divisibility, Primes, The fundamental theorem of arithmetic.
1	**1.2** Congruences: Definition and elementary properties
1	**1.3** Euler's function, and its properties, Fermat's little Theorem, Euler's generalization of Fermat's little Theorem, Wilson's theorem.

Online Resource

NPTEL :: Mathematics - NOC:A basic course in number theory by Dr. Shripad Garge, IIT Bombay (Week 1 Lectures)

Reference Books:

1. An introduction to Theory of Numbers Fifth Edition by Niven, H. Zuckerman and H. Montogoery, Wiley Student Edition
2. Elementary Number Theory Sixth Edition by David M. Burton, Tata-McGraw-Hill
3. An Introduction to Theory of Numbers by G. H. Hardy and E. M. Wright, Oxford University Press
4. A Classical Introduction to Modern Number Theory by K. Ireland and M. Rosen, Springer
5. Number Theory Structures, Examples and Problems by Titu Andreescu and Dorin Andrica, Birkhauser, a part of Springer Science + Business Media
6. A Pythagorean Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer

Part 4: Detailed Scheme Practicals
Code: US-TMA-P-5

Course - Practical Sessions Based on US-TMA-501, US-TMA-502 and US-TMA-503 with implementation using GeoGebra and Sage Math
Total Credit: 03
Titles of Paper: Calculus and Analysis **Credit:01**

Course Code:US-TMA-P501			
Unit	**Content**	**No. of Lectures**	**Reference Books**

I	1.Pointwise and uniform convergence of sequence functions, properties 2. Pointwise and uniform convergence of series functions, properties	02 Lectures per Practical per Batch	Reference No. 1, 2,3
II	3.Double Integration with applications using GeoGebra 4. Triple Integration with applications using GeoGebra		
III-	5.Integration in Vector Fields using Geo Gebra:Line Integral 5.Integration in Vector Fields using Geo Gebra: surface area and surface Integral		

Course Code:US-TMA-P502			**credit:01**
Unit	**Content**	**No. of Lectures**	**Reference Books**
I	1. Properties of Groups with examples of Groups. 2. Abelian Groups and order of an element.	02 Lectures per Practical per Batch	Reference No. 1, 2,3
II	3. Subgroups, Cyclic Groups. 4. Group Cosets, Lagranges Theorem, Permutation Groups with Sage Math.		
III-	5. Normal Subgroups, Quotient Groups with Sage Math. Homomorphism and Isomorphism of Groups.		

Online Reference (For Practical) https://ajitmathsoft.wordpress.com/sagemath/(lec 11,12)

Course Code:US-TMA-P503		**Credit:01**	
Unit	**Content**	**No. of Lectures**	**Reference Books**
I	1.Metric spaces, examples normed , normed linear spaces 2.Open balls, open sets in metric spaces, ,normed linear spaces.	02 Lectures per Practical per Batch	Reference No. 1, 2,3
II	3. Limit points and closure points, closed balls, closed sets, closure of a set. 4. Sequences,subsequences ,Cauchy sequences in a metric Space.		
III-	5Continuity at a point in a metric space and on a Metric Space 6.Uniform Continuity on Metric space and review of Metric Spaces using SageMath		

Online Reference (For Practical 6)
https://doc.sagemath.org/html/en/reference/categories/sage/categories/metric_spaces.html

Part 5. The Scheme of Teaching and Examination

Semester – VI

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (Mathematics)			US-TMA-601, US-TMA-602, US-TMA-603 US-TMA- P-6	
2	Elective Course	Discipline Specific Elective (DSE) Course		US-TMA-604	
		2.1	Interdisciplinary Specific Elective (IDSE) Course		
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)				
	Skill Enhancement Courses (SEC)				

Third year Semester-VI Internal and External Assessment Detail Scheme:

Sr. No.	Subject Code	Subject Title	Periods Per Week						Seasonal Evaluation Scheme				Total Marks
			Units	S. L.	L	T	P	Credit	S. L. E	CT	TA	SEE	
1	US-TMA-601	Complex Analysis	3	20 % *	3	0	0	2.5	10	20	10	60	100

2	US-TMA-602	Algebra II	3	20 % *	3	0	0	2.5	10	20	10	60	100
3	US-TMA-603	Topology of Metric SpacesII	3	20 % *	3	0	0	2.5	10	20	10	60	100
4	US-TMA-604	Number Theory and Applications-II	3	20 % *	3	0	0	2.5	10	20	10	60	100
5	US-TMA-P-6	Practical Sessions Based on US-TMA-601, US-TMA-602 and US-TMA-603 with implementation using GeoGebra and Sage Math	3	-	0	0	3	3				150 (90+60)	150
6		Project	2					3					100
	Total Hours / Credit		16						Total Marks				650

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

Semester – I Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours/Lectures	Total No. of hours/lectures	Credit	Tot al Marks
1	US-TMA-601	I	Complex Analysis	15	45 L	2.5	100 (60+40)
		II	Complex Differentiability and Complex Integration	15			
		III	Complex power series	15			
2	US-TMA-602	I	Introduction to rings and fields	15	45L	2.5	100 (60+40)
		II	Polynomial rings and principal ideal domains	15			
		III	Unique factorization domain	15			
3	US-TMA-603	I	Complete Metric Spaces	15	45L	2.5	100 (60+40)
		II	Compact Metric Space	15			
		III	Sequentially compactness property Connected sets	15			
4	US-TMA-604	I	Quadratic Reciprocity	15	45L	2.5	100 (60+40)
		II	Continued Fractions	15			
		III	Pell's equation, Arithmetic function and Special numbers	15			
5	US-TMA- P-6	I	Practical Sessions Based on US-TMA-501, US-TMA-502 and US-TMA-503 with implementation using GeoGebra and Sage Math	3	30x3= 90L lectures per batch	3	150 (90+60)
			TOTAL			13	550

- **Lecture Duration – 45 Minutes = 0 .75 Hours. (45 Lectures equivalent to 33.75 hours)**
- **One Credit =16.87 hours equivalent to 17 Hours**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination, PA-Project Assessment, AT- Attendance

Part 6: Detailed Scheme Theory

Course I Complex Analysis **Credits 2.5**
US-TMA-601

Objective The objective of this course is to introduce the learner to the Basic Course in Complex Analysis so that with this knowledge they can apply the theories and concepts in the branches of Sciences like Physics.

Unit	Content	No. of Lectures
1	**1. Complex number** 1.1 Complex numbers: Basic Algebraic Properties, modulus, complex conjugates, Representation of complex number in the exponential form, De Moivres formula, nth Roots of unity, Geometric Interpretation of nth roots of unity. The nth roots of unity form a cyclic group under multiplication, Roots of a complex number, Stereographic projection. 1.2 Functions of a Complex variable, Elementary Functions: Complex Exponential function, Complex Logarithmic function, Power functions. Conformal mapping, Fractional linear transformations. 1.3Limits and Continuity: Limit of a complex function at a point, theorems on limits, Limits involving the point at infinity, and Continuity of a complex function at a point.	**15**
2	**Complex Differentiability and Complex Integration** 2.1 Complex Differentiability, sufficient Condition for differentiability. Differentiability implies continuity, L'Hospital's Rule, Cauchy Reimann Equations, analytic functions, Criteria for analyticity, harmonic functions 2.2 Complex Integration: Definite integrals of functions, Contour and Contour Integrals. Absolute value inequality, Evaluation of simple integrals, upper bounds for moduli of contour integrals, anti-derivatives, examples **2.** The Cauchy-Goursat Theorem, Cauchy's Integral formulas And Their Consequences. Cauchy Estimates and Liouville's Theorem. Fundamental Theorem of Algebra	**15**
3	**Complex power series** 3.1 Power series, Taylor series representation, examples. Zeros of an analytic function, 3.2 Isolated singularities: removable singularity, poles, essential singularity, Laurent series representation (statement only) Examples. Identifying singularities by representing function into Laurent series about a point. **3.** Cauchy's Residue theorem (statement), Evaluating Trigonometric Integrals, Improper integrals.	**15**

Reference Books:

1 Complex Variables and Applications, by R.V. Churchill and I.W. Brown, International Student Edition, 2003.

2 Complex Analysis (First edition) by Elias M. Stein & Rami Shakarchi, Overseas Press (India) Private Limited.

3 Complex Analysis, by Theodore W. Gamelin, Springer

Self-Learning topics (Unit wise)

Unit	Topics
1.1	De Moivres formula ,nth Roots of unity, Geometric Interpretation of nth roots of unity. nth roots of unity forms a cyclic group under multiplication, Roots of a complex number
2.1	Differentiability implies continuity, L'Hospital's Rule
2.3	Fundamental Theorem of Algebra

Online Resources

https://archive.nptel.ac.in/courses/111/107/111107056/#
A Web Course in Complex Analysis Swaminathan I.I.T. Roorkee, India and V.K. Katiyar I.I.T. Roorkee, India

https://archive.nptel.ac.in/courses/111/106/111106141/# Complex Analysis By Prof.. Pranav Haridas Department of Mathematics Kerala School of Mathematics

Course III: Modern Algebra II (Ring Theory) **Credits 2.5**

Course Code: US-TMA-603

Objective: The objective of this course is to introduce the learner to the topic of Rings and Field in this Basic Course in Modern Algebra .

Unit	Content	No. of Lectures
1	**An Introduction to Rings, Fields** 1.1. Definition and properties of Rings and Subrings. 1.2. Integral Domains and Fields. 1.3. Ideals and Factor Rings.	**15**
2	**Polynomial Ring and Principle Ideal Domain** 2.1. Homomorphism of Rings, Prime Fields, Quotient Fields. 2.2. Polynomial Rings, Principle Ideal Domain	**15**
3	**Unique Factorization Domain** 3.1. Factorization of Polynomials. 3.2. Divisibility in Integral Domains.	**15**

Reference Books:

1. Joseph, A. Gallian, Contemporary Abstract Algebra,(4th Edition), Narosa Publishing House.
2. J. B. Fraleigh, First course in Abstract Algebra (4rd Edition). Narosa Publishing House.
3. I. N. Herstein. Abstract Algebra, (3rd Edition), Prentitice Hall of India, 1996.
4. N. S. Gopalkrishnan, University of Algebra, Wiley Eastern 1986.
5. C. Musili, Rings and Modules, Narosa Publishing House, 1992.

Online Resource

https://archive.nptel.ac.in/courses/111/106/111106131/#watch
(link for NPTEL lecture INTRODUCTION TO RINGS AND FIELDS by , PROF. KRISHNA HANUMANTHU Department of Mathematics Chennai Mathematical Institute)

Course III: **Course Code: US-TMA-603** **Credits:2.5**

Topology of Metric Spaces - II

Objective: Learner will be introduced to the important concepts of Topology of Metric Spaces And it's applications.

Unit	Content	No. of Lectures
1	**Complete metric spaces** 1.1 Convergent sequences, Cauchy's principle of convergence, Complete metric spaces. Completeness property in subspaces of a complete metric space. 1.2 Cantor's intersection theorem. Examples of Complete metric spaces: $\mathbb{R}$, $\mathbb{R}^n$, $\square$ [a, b]. 1.3 If X, Y are complete metric spaces with metrics d_1, d_2 respectively, then X × Y is complete with metric $d((x_1, y_1), (x_2, y_2)) = \sqrt{\square_1(\square_1, \square_1)^2 + \square_2(\square_1, \square_2)^2}$	**15**

	Examples of incomplete Metric Space	
2	**Compact metric spaces** 2.1 Definition of a compact set in a metric space as a set for which every open cover has a finite subcover, examples. Continuous functions on Compact Metric Spaces. 2.2 Compactness and finite intersection property, A compact metric space is complete. 2.3 Characterization of compact sets in $\mathbb{R}^n$: The following are equivalent statements for a subset of $\mathbb{R}^n$ to be compact: 1. Heine-Borel property. 2. Closed and boundedness property. 3. Bolzano-Weierstrass property.	**15**
3	**Sequentially compactness property** **Connected sets** 3.1 Connected metric spaces (a metric space which cannot be represented as the union of two disjoint non-empty open subsets). Characterization of a connected space, namely a metric space X is connected if and only if every continuous function from X to the discrete metric space {1, 1} is a constant function. Connected subsets of a metric space, connected subsets of $\mathbb{R}$ are intervals. A continuous image of a connected set is connected, applications such as: i) GL(2, $\mathbb{R}$), $O(n, \mathbb{R})$ are not connected, ii) graph of a real valued continuous function defined on an interval is a connected subset of $\mathbb{R}^2$. 3.2 For A, B be two connected subsets of a metric space X, i) $A \cap B \neq \emptyset$ implies $A \cup B$ is connected, ii) $A \subset B \subset \square\square$ implies B is connected. Circle S^1 is a connected subset of $\mathbb{R}^2$. 3.3 Definition of a path connected metric space, examples including $\mathbb{R}^n$, $S^n (n \in N)$. A path connected metric space is connected and applications including connectedness of $\mathbb{R}^n$, $\mathbb{C}^n$. An example of a connected subset of $\mathbb{R}^2$ which is not path connected (proof not required). An open subset of $\mathbb{R}^n$ is connected if and only if it is path connected (proof not required).	**15**

Reference Books:

1 Topology of Metric spaces, by S. Kumaresan, Narosa.
2 Metric Spaces, by P. K. Jain, K. Ahmed, Narosa, New Delhi, 1996.
3 Introduction to Topology and Modern Analysis, by G.F. Simmons, McGraw Hill Education (India) Edition.
4 Principles of Mathematical Analysis, by W. Rudin, Tata McGraw- Hill Education in 2013

5 Mathematical Analysis, by T. Apostol, Narosa.
6 Methods of Real Analysis by R. R. Goldberg.
7 Metric Spaces, by E. T. Copson, Universal Book Stall, New Delhi,

Course IV: **Course Code: US-TMA-604** **Credits: 2.5**

Number Theory and its application II (Elective A)

Objectives:

1. Learners will learn computational techniques (Legendre and Jacobi symbols) in number theory.
2. Learners will learn interconnections between integers and rational and complex numbers.

Unit	Content	No. of Lectures
1	**1.** Quadratic Reciprocity **1.1** Quadratic residues and Legendre symbol, Gauss Lemma. **1.2** Theorem on Legendre symbol $(\frac{2}{\square})$, the result: If p is an odd prime and a is an odd integer, then $(\frac{\square}{\square}) = (-1)^{\square}$ where $\square = \sum_{\square=1}^{\frac{\square-1}{2}} [\frac{2\square}{\square}]$ **1.3** Quadratic Reciprocity law. Theorem on Legendre Symbol $(\frac{3}{\square})$. **1.4** The Jacobi symbol and law reciprocity for Jacobi symbol **1.5** Quadratic Congruences and Composite moduli	**15**
2	**2. Continued Fractions** 2.1. Finite continued fractions. 2.2. Infinite continued fractions and representation of an irrational number by an infinite simple continued fraction. 2.3. Rational approximations to irrational numbers and order of convergence 2.4. Periodic continued fractions	**15**
3	**3. Pell's equation, Arithmetic function and Special numbers** 3.1. Pell's equation $\square^2 - \square\,\square^2 = \square$, where $\square$ is not a square of an integer. Solutions of Pell's equation 3.2. Arithmetic functions of number theory: $\square(\square)(\square\square\ \square(\square),$ $\square_{\square}(\square), \square(\square))$and their properties, $\square(\square)$ and the Mobius inversion formula. 3.3. Special numbers: Fermat numbers, Mersenne numbers, Perfect numbers, Amicable numbers, Pseudo primes, Carmichael numbers.	**15**

Self-Learning topics (Unit wise)

Unit	SLE Topics
3	3.1 Pell's equation $\square^2 - \square\,\square^2 = \square$, where $\square$ is not a square of an integer. Solutions of Pell's equation
3	3.3 Special numbers: Fermat numbers, Mersenne numbers, Perfect numbers, Amicable numbers, Pseudo primes, Carmichael numbers.

Online Resource

NPTEL :: Mathematics - NOC:A basic course in number theory by Dr. Shripad Garge, IIT Bombay (Week 1 Lectures)

Reference Books:

1. An introduction to Theory of Numbers Fifth Edition by Niven, H. Zuckerman and H. Montogoery, Wiley Student Edition
2. Elementary Number Theory Sixth Edition by David M. Burton, Tata-McGraw-Hill
3. An Introduction to Theory of Numbers by G. H. Hardy and E. M. Wright, Oxford University Press
4. A Classical Introduction to Modern Number Theory by K. Ireland and M. Rosen, Springer
5. Number Theory Structures, Examples and Problems by Titu Andreescu and Dorin Andrica, Birkhauser, a part of Springer Science + Business Media
6. A Pythagorean Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer

Part 7: Detailed Scheme Practicals
Code: US-TMA-P-6

Course - Practical Sessions Based on US-TMA-601, US-TMA-602 and US-TMA-603 with implementation using GeoGebra and Sage Math

Total Course Code: US-TMA-P-6

Credit: 03

- Practical Sessions Based on US-TMA-601		**Credit:01**	
Unit	**Content**	**No. of Lectures**	**Reference Books**
I	1.Limit continuity and derivatives of functions of complex variable 2Fractional linear (Mobius) transformations	02 Lectures per Practical per Batch	Reference No. 1, 2,3
II	Analytic (Holomorphic) Function, Evaluation of simple integrals, upper bounds for moduli of contour integrals, anti-derivatives, Cauchy integral formula, finding harmonic conjugate, examples		
III-	Taylor series, power series, Finding isolated singularities- removable, pole and essential, Laurent series, calculation of residue		

Practical Sessions Based on US-TMA-P602		**credit:01**	
Unit	**Content**	**No. of Lectures**	**Reference Books**
I	1. Properties of Rings, Subrings and Integral Domains. 2. Fields, Ideals and Factor Rings.	02 Lectures per Practical per Batch	Reference No. 1, 2,3,4 Online Reference
II	3. Homomorphism of Rings, Prime Fields, Quotient Fields. 4. Polynomial Rings and Principle Ideal Domain.		
III-	5. Factorization of Polynomials. 6. Divisibility in Integral Domains.		

Course Code:US-TMA-P603		Credit:01	
Unit	**Content**	**No. of Lectures**	**Reference Books**
I	1. Continuity, Uniform Continuity, 2. Examples of complete Metric Space, incomplete Metric Space	02 Lectures per Practical per Batch	Reference No. 1, 2,3
II	3. Compact sets in a metric space, Compactness in $\mathbb{R}^n$ (emphasis on $\mathbb{R}$, $\mathbb{R}^2$) properties. 4. Continuous image of a compact set, Example of a closed and bounded subset of a metric space which is not compact.		
III-	5. Connectedness, Path connectedness, 6. Continuous image of a connected set.		

III. Evaluation of Project work (courses: USMTPJ5 & USMTPJ6): Select Separate Topic for both the Semesters. There will be 2 contact hours per project per week.

Total Credits: 3

The evaluation of the Project submitted by a student shall be made by a Committee appointed by the Head of the Department of Mathematics of the respective college. The presentation of the project is to be made by the student in front of the committee appointed by the Head of the Department of Mathematics of the respective college. This committee shall have two members, possibly with one external referee. The Marks for the project are detailed below:

Contents of the project: 40 marks

Presentation of the project: 30 marks

Viva of the project: 30 marks.

Total Marks= 100 per project per student

Suggested topics for projects: (*not limited to)

1. **Powers of Integers**. Reference: Chapter 2 of Number Theory Structures, Examples and Problems by Titu Andreescu and Dorin Andrica, Birkhauser, a part of Springer Science + Business Media

2. **Sequences of Integers: Fibonacci and Lucas Sequences, Linear Recurrence Relations**. Reference: Chapter 9 of Number Theory Structures, Examples and Problems by Titu Andreescu and Dorin Andrica, Birkhauser, a part of Springer Science + Business Media
3. **Binomial Coefficients, Lucas's and Kummer's Theorems.** Reference: Chapter 10 of Number Theory Structures, Examples and Problems by Titu Andreescu and Dorin Andrica, Birkhauser, a part of Springer Science + Business Media
4. **Integral Solutions to Pythagorean Equations.** Reference: Chapter 3 of A Pythagorean Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer
5. **What integers are areas of right triangles?** Reference: Chapter 4 of A Pythagorean

Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer

6. **What integers are the edges of a right triangles?** Reference: Chapter 5 of A Pythagorean Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer
7. **Quadratic Forms with Integral Coefficients.** Reference: Chapter 12 of A Pythagorean Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer
8. **Number of Lattice Points on a Circle.** Reference: Chapter 9 of A Pythagorean Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer
9. **Lehmer's Theorem (an asymptotic formula for the number of primitive right triangles with bounded hypotenuse)** Reference: Section 13.1 of A Pythagorean Introduction to Number Theory: Right Triangles, Sums of Squares and Arithmetic by Ramin Takloo-Bighash. Springer
10. **Fourier series, Orthogonal Functions, Dirichlet's problem**: G. F. Simmons, Differential Equations with Applications and Historical Notes, McGRAW-Hill International
11. **Maximum principle for analytic functions and applications**: Lars Ahlfors,
12. **Plotting regions under Mobius Transformations**: S. Lang, Complex Analysis, Springer.
13. **Errors Analysis for various Numerical Methods to solve Transcendental and Polynomial Equations and implementation of Python Programming**. S. Sastry, Introductory methods of Numerical Analysis, PHI Learning.
14. **Numerical Methods to solve Linear System of Equations, and implementation of Python Programming.** S. Sastry, Introductory methods of Numerical Analysis, PHI Learning.
15. **Various Sorting Algorithms like merge sort, insertion sort, quick sort, heap sort, bucket sort, radix sort: Analysing Time estimation of these algorithms. Also writing programs in Python** References: Kenneth H. Rosen: Discrete Mathematics and Its Applications, McGraw Hill Edition., R.G. Dromey, How to Solve it by Computer, Pearson Education.
16. **Transportation Problems- VAM method** References: Operation Research Theory & Applications- J K Sharma, Operation Research- Hamdy Taha, An introduction to Management Science- Anderson Sweeney.
17. **CPM & PERT.** References: Operation Research Theory & Applications- J K Sharma, Operation Research- Hamdy Taha, An introduction to Management Science- Anderson Sweeney.