Annexure: I

Faculty of Science

Department of Mathematics

Ordinance, Curriculum & Syllabus

Master of Science (Mathematics)

(2020-21)

Shree Guru Gobind Singh Tricentenary

University, Gurugram (Haryana)- 122505, India

SHREE GURU GOBIND SINGH TRICENTENARY (SGT) UNIVERSITY,
BUDHERA, GURUGRAM (HARYANA)
FACULTY OF SCIENCE
MASTER OF SCIENCE [MATHEMATICS]
ORDINANCE

1. PREAMBLE

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of the country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning (online & offline) process, examination and evaluation systems, besides governance and other matters.

The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system.

Department of Mathematics, Faculty of Science, Shree Guru Gobind Singh Tricentenary University, Gurugram with the aim to enhance academic standards in quality of higher education has adopted the UGC guidelines in its Postgraduate (PG) program (M. Sc. Mathematics).

The grading system is considered to be better than the conventional marks system and in order to facilitate student mobility across institutions within India and across countries the community grade point average (CGPA) has been introduced in this PG program. The guidelines are as follows:

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed pool of courses comprising core, elective, skill and ability enhancement courses. The courses can be evaluated by a uniform grading system in the higher education system. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in the evaluation system

and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Outline of Choice Based Credit System:

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

b. **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.

   i. **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).

   ii. **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.

c. **Skill Enhancement Course:** The course based upon the content that leads to Knowledge enhancement.

d. **Ability Enhancement Compulsory Course:** The course based upon the content that leads to the development of a professional of ability.

e. **Open Elective Course:** The course based upon the content that enhances interdisciplinary knowledge

2. Program Educational Objectives (PEOs):

1. To equip students with knowledge of fundamentals and advancement in pure and applied mathematics.

2. To create heuristic approach of solving mathematical and analytical problems among the students.

3. To develop interest of students in pure and applied mathematical research areas with a focus on sustainable development and useful innovation.

4. To make the students capable of demonstrating their ideas and solutions in the form of technical writing and through oral presentation.
5. To make them competent of practicing professional ethics and emerging as a skilled leaders in the field of mathematics.

3. Program Outcomes (POs):

On successful completion of the Program, students will have the ability to:

1. **Disciplinary Knowledge:** Develop the capability of demonstrating comprehensive knowledge in pure and applied mathematics.
2. **Critical Thinking & Problem Solving:** Analyze the mathematical results and use them to solve various real world problems in mathematics as well as in other related scientific domains.
3. **Analytical/Scientific Reasoning:** Apply appropriate techniques for the qualitative and quantitative analysis of mathematics and explore the scientific reasoning for the obtained results.
4. **Research-related Skills:** Develop the capability of writing basic research project in emerging areas of pure and applied mathematics.
5. **Social Interaction & Effective Citizenship: P**repare students to gain the social competency and skills to handle the growing and ever widening mathematical origin requirements in the civilization.
6. **Effective Communications: E**xplain the complex mathematical problems through technical report writing, documentation, poster/oral presentation and group discussion during seminars, workshops and conferences.
7. **Multi-culture competence & Leadership Readiness:** Work effectively either independently or as a team leader while being adaptable to various multicultural professional environments.
8. **Environment & Sustainability:** Understand the impact of the mathematics to solve various problems in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
9. **Ethics:** Identify unethical behavior such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

10. **Self-directed and Life-long learning:** Work independently, do in-depth study of various notions of mathematics and inculcate the habits of self-learning to lead.

4. Definitions

i. **Course** means a unit of teaching / individual subject comprising of Lectures, Tutorials and / or Lab that typically lasts one academic term (semester / year) led by one or more instructors (teachers or professors), and has a fixed roster of students. Each Course shall have an individual Course Code e.g. Numerical Analysis and Application (theory) and Numerical Analysis and Application (Lab) to be given separate course codes.

ii. **Credit** means a unit by which course work is measured. One hour of lecture / tutorial is equal to one credit and one hour of lab / workshop / project etc. is equal to half credit.

iii. **Program** means any combination of courses and/or requirements leading to a degree, diploma or certificate e.g. M.Sc. (Mathematics).

iv. **Program Structure** means listing of various courses of a program and the credits associated with them as L-T-P structure which indicates the number of lecture hours/week, number of tutorial hours/week and number of practical hours/week to be devoted for each course e.g. Ordinary differential Equations (3-0-2). This means that this course shall have 3 hours of lecture per week and 4 hours of practical work per week.

v. **Scheme of Study** means the Academic Term wise listing of all the courses along with distribution of their formative and summative assessment criteria, which will be normally offered during the entire Program.

vi. **Semester Grade Point Average (SGPA)** means the ratio of sum of the product of the number of credits with the numerical grade scored by a student in all the courses taken by a student in a particular Semester and the sum of the number of credits of all the Courses undergone by a student, i.e. $SGPA(Si) = \sum (Ci \times Gi) / \sum Ci$.

vii. **Cumulative Grade Point Average (CGPA)** means the ratio of sum of the product of the number of credits with the numerical grade scored by a student in all the courses taken by a student in all Semesters and the sum of the number of credits of all the Courses undergone by a student i.e, $CGPA = \sum (Ci \times Si) / \sum Ci$.

viii. **Open Elective Course** means a course offered by a Department / Faculty other than the parent Department / Faculty.

5. Duration and Nomenclature of the Program:

The duration of M.Sc. Mathematics program shall be of two academic years consisting of four (04) semesters (16 weeks per semester) under Choice Based Credit System (CBCS). On successful completion of all the four semesters, the student will be awarded M.Sc. Mathematics degree. The student shall complete the program within a maximum period of 4 years from the date of admission to the first semester as per N+2 rule by UGC (where N stands for minimum duration years of the program). However, in exceptional circumstances a further extension of one more year may be granted. In such cases, permission from competent authorities of the University is mandatory, failing which he/she will be disqualified from the program.

6. **Eligibility criteria for Admission in a Program**

For admission to the 1st Semester of M.Sc. (Mathematics) program, the candidate must have passed B.Sc. (Pass) with Mathematics as one of the subjects/B.Sc. (Hons.) Mathematics with 50% marks (45% marks in case of SC/ST candidates of Haryana only) in aggregate or equivalent grade from any university recognized by UGC.

7. **Registration of Courses at the start of an academic term**

Every student admitted in a Program shall be required to register various courses which he/she needs to undergo in a particular Semester as per the approved Scheme of Study applicable to M.Sc. Mathematics Program in the prescribed format within the defined timelines.

8. **Medium of Instructions:**

The medium of the instructions for all Programs shall be English only.

9. **Scheme of Study and Syllabi**

(i) Scheme of Study and Syllabi shall be governed by the UGC regulations.

(ii) In M.Sc. Mathematics, formal classes / labs shall be held for 5 days in a week i.e. Monday to Friday and Saturday shall be reserved for Professional Activities (Curricular / Co-curricular and Extra-Curricular).

(iii) Minimum number of Credits required to earn M.Sc. Mathematics degree shall be 82 credits.

(iv) Provision has been made in the Scheme of Study for students to earn up to three credits in each Semester through online MOOC courses on the specified portals.

For example, a student may enroll in the courses offered on SWAYAM platform of the Government of India (https://swayam.gov.in/). The courses offered on SWAYAM on

SWAYAM portal are offered by the top ranked Universities / Institutions of National Importance spanning 4-12 weeks in higher education domain. A 4-week, 8 week and 12 or more week courses may have 1, 2 & 3 credits respectively. The credits will be accepted if the student appears in the term end examination conducted by the host institution and earns credits for the same with appropriate grade. Similarly, other such platforms may be identified by the department time to time.

(v) For Open Elective Course, a slot of one hour (preferably last lecture) during first three days of the week (Monday to Wednesday) for the whole semester will be earmarked in the time table.

(vi) The syllabus of various theory courses has been designed and distributed in four units and is balanced in terms of Academic workload (e.g. the syllabus has been designed in such a way that the entire theory syllabus is to be covered in 11C hours where C means number of credits per week. 2C/3C hours shall be utilized for discussing performance of the students in class test/assignment and covering currently relevant topics related to the subject).

(vii) The weightage of continuous/ formative evaluation and term-end/ summative evaluation for theory classes is in the ratio of 40 and 60 respectively. Every course has 100 marks for evaluation.

(viii) Continuous/ Formative Evaluation of theory courses is done in following manner:

a) Mid Semester Examination (Subjective/Objective, Average of two) : 20 Marks
b) Assignments (Average of two) : 10 Marks
c) Professional Activities (Problems/Projects/Seminars/Case Study etc.) : 10 Marks

(ix) A student will be required to register for Professional Activities in the very beginning of the Academic Term (semester) which will be open ended and consists of curricular / co-curricular / extra-curricular activities. Such activities will include extra projects beyond syllabus (SGTU Synergy / Competitive Projects such as Hackathon / Robocon /BAJA/ SAE etc.), extension and activities related to clubs / societies / chapters of professional bodies / NSS / NCC / Sports etc. Each such activity shall be undertaken by the student under the supervision of a Faculty Member who will keep records of the activity undertaken by the student. Faculty Mentor concerned shall be informed about all the activities being undertaken by every student. Each student shall maintain a diary / log book of activities perform by her/him which will be countersigned by the Faculty

Activity in-charge on fortnightly basis. Three weeks before the last day of classes, every student shall submit a portfolio of activities performed by him/her along with diaries / log books to the Faculty Mentor concerned. Head of the Department concerned shall constitute a Portfolio Evaluation Committee consisting of two Faculty members of the Department and a representative of Dean Student Welfare. Portfolio Evaluation Committee shall evaluate the performance of each student separately and award marks on scale of 0 to 10 based upon the efforts put by each student and the outcomes. Portfolio Evaluation Committee shall submit the evaluation report to the Head of the Department concerned who after satisfying herself/himself about the quality of evaluation shall notify the marks to all the Teachers taking theory classes in that Semester for incorporating marks earmarked for professional activities. Such professional activities shall be undertaken on week days after working hours and Saturdays. This provision / evaluation shall measure the group activities, attitude and behavior of the student.

(x) The weightage of continuous/formative evaluation and term-end/summative evaluation of lab classes/summer training/project work are in the ratio of 60 and 40 respectively. Every lab course has 100 marks for evaluation.

(xi) Continuous/Formative Evaluation of lab courses is done in following manner: -

a)	Attendance and Regularity in Lab Work	:	10 Marks
b)	Lab/Project Work Report	:	10 Marks
c)	Mid Term Oral Exam./ Assessment	:	10 Marks
d)	Conduct/ Demonstration	:	30 Marks

The distribution of formative (internal) assessment marks for the summer training and project work to be kept in-line with the above.

10. Teacher Diary and Course File

(i) Every faculty member should maintain a separate Teacher Diary and a Course file for each course including lab courses.

(ii) Teacher Diary will be maintained in the pre-printed booklet issued from the university store which consists of Index, Syllabus (Theory and Lab), Subject Time Table, Course plan, Daily Diary (Course Coverage), Attendance Record, Evaluation (Internal Assessment) Record, List of Low Performing Students, Value Added Lecture Plan,

Internal Practical (Continuous Evaluation) marks for laboratory, Parent Teacher Meeting Record etc.

(iii) Each course file shall contain the following:

- Syllabus
- Learning Resources prescribed
- Tutorial Sheets / Assignments
- Current and Previous Class Test / Sessional Question Papers
- Previous Term-End Examination Question Papers
- Lecture Notes (In the Current file only).

(iv) At the end of the semester, faculty member should submit Teacher Diary and Course File to HODs. HODs shall maintain the record of all course files for at least 5 years.

(v) Faculty member can withdraw his or her handwritten notes from the course file before submitting to HODs.

(vi) In case, Faculty member is allotted same subject in the next semester, then he/she can take same course file from Principal / HODs for few days for the reference purpose only.

11. Home Assignments

a) Home Assignment will be designed as per the final examination pattern as per the details given in the table.

		No of Questions per Assignment									
		1 Mark	2 Marks	4 Marks		6 Marks	10 Marks	12 Marks	Total Marks	Time Per Assignment (Minutes)	Total Time (Hrs.)
		Marks	1	2	4	6	10	12			
S. No.	Examination Pattern	No of Assignments	2.5	6	10	15	25	30			
1	Pattern	Two per course / One per two units	10	10	5	3	0	0	68	180	120

b) Minimum one home assignment shall be given from every two units.

Penalty for late submission of Home Assignment

a) Every Home Assignment shall have the Date of Release and last Date of Submission.

b) Penalty for late submission for Home Assignment in the form of %age of marks deduction shall be as under:

- Within 7 Calendar days: 20%
- Within 8 to 15 Calendar days: 40%
- More than 15 Calendar days: 50%

c) Teachers will ensure that there is no plagiarism in Home Assignment. If plagiarism is detected, a penalty of 30% may be levied and the student will be asked to re-submit the Home Assignment within 7 Calendar days.

12. Question Banking and Question Paper Setting for Term End Examination

(i) Question Banking for Term End Evaluation and home assignments shall be done with questions having 1, 2, 4 and 6 marks. The time allotted to each question shall be as under: -

Description	**Marks**			
	1	**2**	**4**	**6**
Term End Examination is for 60 marks	2.5 minutes	5 minutes	10 minutes	15 minutes

(ii) Each question shall be set in the following format: -

S. No.	**Question**	**Marks Allotted**	**Time Allotted**	**Bloom Taxonomy (Cognitive Domain) Level**	**Difficulty Level**	**Course Outcome Number**

(iii) Bloom Taxonomy (Cognitive Domain) levels shall be: Knowledge, Comprehension, Application, Analysis, Evaluation and Synthesis.

(iv) Difficulty levels shall be: Easy, Moderate and Difficult.

(v) Course Outcome Number shall be the number of specific outcomes given in the Course Objective and Course Outcome Matrix.

(vi) Term-End Examination question papers shall be set for all courses as per pattern given in the following table:

Question Paper Setting											
			No of Questions per subject								
			1 Mark	**2 Marks**	**4 Marks**	**6 Marks**	**10 Marks**	**12 Marks**	**Case Study**	**Maximum Marks**	**Total Time (mins)**
S.No.	**Examination Pattern**	**Marks**	**1**	**2**	**4**	**6**	**10**	**12**	**40**		
		No of Units↓/ Time→	**2.5**	**5**	**10**	**15**	**25**	**30**	**NA**		
1	Pattern	4	12	4	4	4	0	0	NA	60	150.0

Guidelines

a. Duration of end term theory examination: 3 hours.

b. Maximum marks: 60.

c. All Questions shall be compulsory.

d. The Question paper will be divided into four sections A, B, C and D.

e. Section A is compulsory and comprises of 12 questions of one mark each, 3 from each unit. The questions shall be asked in such a manner that there are no direct answers including one word answer, fill in the blanks or multiple choice questions (2.5 minutes each)

f. Section B comprises of 4 questions of 2 marks each, one from each unit. (5 minutes each)

g. Section C Comprises of 4 questions of 4 marks each, one from each unit. (10 minutes each). Each question may have two alternatives, out of which student will be required to attempt one.

h. Section D Comprises of 4 questions of 6 marks each, one from each unit. (15 minutes each). Each question may have two alternatives, out of which student will be required to attempt one.

i. The questions shall be set in such a manner that these cover first five level of Bloom Taxonomy i.e. Knowledge (10-15%), Comprehension (15-25%), Application (15-25%), Analysis (15-25%) and Synthesis (10-15% in normal papers; 50-80% in design papers).

j. The questions shall have three difficulty level namely Easy, Moderate and Difficult with ratio of 1:2:1 respectively.

k. Each question will be linked with the relevant CO.

13. Examination Scheme for Mid Semester Question Papers/ Class Test

(i) Mid Semester Question Papers/ Class Test shall be held normally in 7th and 13th weeks in the semester. Question papers shall be set from minimum 2 units (50% syllabus of each course). Duration shall be 90 minutes. Maximum marks shall be 30.

(ii) The structure of the sessional question papers shall remain the same as in term-end examination question paper.

14. Attendance Requirements/Eligibility to Appear in Term End Examination

(i) A student should have minimum 75% attendance in each Course to be eligible to appear in Term End Examination failing which she/he shall be detained from appearing in the Term End Examination of that particular Course. A maximum condonation to the extent of 10% may be granted by the Dean of Faculty of Science based upon genuine reasons such as hospitalization of self / parents / siblings, death in the family, participation in University sponsored activities outside the University campus and voluntary blood donation etc.

(ii) It will be the responsibility of the student to keep a track of her/his attendance in each Course in an Academic Term (semester) through ERP Portal and / or Course Teacher.

(iii) If a student is detained in a particular case, she/he shall be required to make-up the deficiency of attendance in the subsequent Academic Terms by attending classes, appearing in class tests and submitting additional home assignments. Once such student has made-up the deficiency, she/he will be allowed to appear in the next supplementary examination.

(iv) If the deficiency is more than 25% in a particular Course (having less than 50% attendance), the student will be required to pay additional fee specified by the university time to time for attending the classes again for which she/he will have to register for the Course(s) again in the subsequent term with the approval of the HOD/Dean concerned.

15. Term End Examination Rules

i. The Term End examination for all semesters shall ordinarily be held in the month of December and May/June for all regular and reappear candidates. The examination dates are fixed by the Controller of Examination with the approval of Vice Chancellor.

ii. Examination Rules including appointment of Examiners, Evaluation of answer sheets, compilation of results, calculation of SGPA/CGPA etc. shall be notified separately.

iii. Answer sheets for the Term End Examination shall be shown to the Examinees before compilation of result by the Faculty members as per schedule (normally in two parts) notified by Head of the Department concerned in consultation with the Controller of Examination.

iv. Normally the schedule for showing answer sheets to the examinees shall be so prepared that they are shown bulk of the answer sheets before last regular examination. Answer sheets related to last two/three exams can be shown within a week from the last date of examination.

v. If a student raises objection to the award of marks in a particular answer sheet, the same shall be considered by a Committee of two Faculty members appointed by Head of the Department and settled on the same day with the approval of Head of the Department concerned.

vi. No request for re-evaluation of answer sheets shall be entertained after the declaration of results.

16. Project / Dissertation

i. Topic Selection and Appointment of Guide/Supervisor: - Normally selection of project topic / research problem shall be finalized in the previous Semester. HOD concerned shall call applications for allotment of project topic / research problem from the students minimum six weeks before the last date of classes in the previous Semester along with a detailed proposal in the specified format.\

ii. HOD concerned shall constitute a Committee for allotment of project topic / research problem for dissertation consisting of minimum 3 Faculty members. The Committee will interview each student and submit the proposed project topic/research problem for each student along-with the suitable Project / Research Supervisor name. HOD shall approve the recommendation of the committee after satisfying herself/himself about the project topic, research problem and the recommended Supervisor. In case, a Project requires a team activity in an undergraduate program, project team shall not have more-than 3 members and role of each team member shall be well defined.

iii. Student shall start working on the literature review in the previous Semester itself and start the project / research activities right from day-1 of the Academic Term in which the Project / Dissertation is included in the Scheme of Study.

iv. It will be mandatory for each student to publish/write at-least one review / research paper in SCOPUS / Web of Science indexed Journal to become eligible for the award of postgraduate degree. For the purpose of eligibility for the award of degree acceptance by the Journal will be sufficient.

v. Each student/team, as the case may be, shall submit minimum 3 copies of Project Report/ Dissertation in the specified format.

vi. Evaluation of Project/ Dissertation: A project/ dissertation undertaken by students shall be evaluated by a panel consisting of one external and one internal examiner. External examiner shall be appointed by the Dean of Faculty concerned out of the panel approved by the Vice Chancellor.

17. Internship / Field Training

The duration of the Internship will be 4 weeks of 4 credits. The formative and summative assessment marks are mentioned in the scheme of study. The final viva voce and reports will be adjudged by the joint Board of External and/or Internal Examiners.

18. Setting of Question Papers:

i. The Head of the Department/Dean of the Faculty shall supply the panel of internal and external examiners duly approved by the Board of Studies to the Controller of Examinations. The paper(s) will be set by the examiner(s) nominated by the Vice-Chancellor from the panel of examiners.

ii. An examiner shall be allowed to set not more than two papers in a semester examination.

iii. The examiner(s) will set the question papers as per criteria laid down in the Scheme of Examinations as approved by the Board of Studies/Academic Council of the University.

19. Evaluation Process – Theory and Practical:

i. **Evaluation of Answer Books**:

The answer books may be evaluated either by the paper setter or any other internal or external examiner to be nominated by the Controller of Examiners with the approval of the Vice-Chancellor from the panel of examiners approved by the Board of Studies.

ii. **Fail/ Reappear candidates:**

Fail / Re-appear (Internal/External) candidate of any semester may appear in the re-appear exams, as an ex-student, during any term end exams of his/her remaining semesters and up to two years after his final semester as per N+2 rule.

iii. **Practical Examinations - Appointment of Examiner:**

The practical examinations shall be conducted by a Board of two Examiners consisting of one internal and one external examiner to be nominated by the Vice-Chancellor from the panel of examiners.

iv. **Marks Distribution:**

The distribution of marks in examination of the practical course will be as per the criteria given below:

a. Demonstration/Conduct/Presentation = 50% marks

b. Viva-Voce Examination = 50% marks

20. Evaluation and Gradation Criteria

Evaluation and Gradation Criteria for Continuous / Formative Assessment and Term End / Summative Assessment shall be followed as mention below:

(i) Minimum pass percentage will be 40% for Continuous/Formative Assessment and 40% for Term End/Summative Assessment respectively in all Theory/Practical Courses, making overall minimum pass percentage to be 40%.

(ii) If a student fails to obtain minimum 40% marks in Continuous/Formative Assessment in a Theory paper, he/she will be required to improve the same by appearing in additional class tests and submitting additional assignments before the close of the Academic term. Such students will be allowed to appear in the Term End Examination of that particular Course provided he/she meets the minimum attendance criteria. However, If a student fails to meet the minimum requirement of 40% marks in Continuous/Formative Assessment before the Term End Exams, his/her result in that course will be shown as RL (FCA), in which case he/she will be required to obtain minimum 40% marks in Continuous/Formative Assessment by appearing in additional class tests and submitting additional assignments in subsequent terms.

(iii) If a student fails to obtain minimum 50% marks in Continuous / Formative Assessment in a Theory paper, she/he will be required to improve the same by appearing in additional class tests and submitting additional assignments before the close of the Academic Session. If a student still fails to meet the minimum requirement of 50% marks in Continuous / Formative Assessment, her/his result in that course will be shown as RL (FCA), in which case she/he will be required to obtain minimum 50% marks in Continuous / Formative Assessment by appearing in additional class tests and submitting additional assignments in subsequent Terms. Such students will be allowed to appear in the Term End Examination of that particular Course provided she/he meets the minimum criteria.

(iv) The Letter and Numerical Grades for different range of percentage of marks obtained in Continuous and Term End Assessment together in a particular Course shall be as under:-

Percentage of Marks Obtained	**Letter Grade**	**Numerical Grade**	**Performance Level**
90% and above	O	10	Outstanding
80% and above but less than 90%	A+	9	Excellent
70% and above but less than 80%	A	8	Very Good

60% and above but less than 70%	B+	7	Good
50% and above but less than 60%	B	6	Above Average
Above 40% but less than 50%	C	5	Average
Minimum Pass Marks 40%	D	4	Pass
Below 40%	F	0	Fail

(v) If it is required to calculate the percentage of marks obtained by a student for the entire Program, the same will be calculated by multiplying overall CGPA with a factor of 10.

(vi) Grace marks of maximum 1% of the Theory courses may be permitted in a particular Semester.

21. Declaration of Results:

i. The Controller of Examinations shall declare the results as early as possible after the conclusion of each examination, but before the start of teaching for the next academic session.

ii. Each successful student/ the student placed in reappear shall receive a copy of the Detailed Marks Certificate/ Grade Card Sheet of each semester examination.

iii. The student whose result is declared late without any fault on his/her part may attend classes for the next higher semester provisionally at his /her own risk and responsibility, subject to his /her passing the concerned semester examination. In case, the student fails to pass the concerned semester examination, his/her attendance/internal assessment in the next higher semester in which he / she was allowed to attend classes provisionally will stand cancelled.

22. Criteria for Promotion to Higher Semester(s):

All students shall be promoted to the next semester / year irrespective of the number of papers cleared/passed in the lower semesters.

23. Improvement of Division after the award of Degree

(i) A student may re-appear for improvement in not more than 5 theory papers only after award of degree within one year from the date of declaration of result of the last / final

examination to improve his/her Division after depositing the prescribed Examination Fee as notified by the University from time to time.

(ii) In the case of re-appearance in paper, the result will be prepared on the basis of the candidate's best performance in either of the Examination.

24. Striking off the name of the defaulting students from the rolls of the University

(i) If a student remains absent for a continuous period of seven working days without written authorization from the Head of the Department of concerned, her/his name shall be struck off from the rolls of the University. However, such students may be re-admitted on payment of the Re-admission fee as prescribed by the University from time to time; if Dean/Principal is satisfied that re-admission of the student will not fall short of requisite percentage of the attendance.

(ii) If a student fails to pay fees by the last cut of date as prescribed by the University from time to time, her/his name shall be struck off from the rolls of the University. However, such students may be re-admitted on payment of the Re-admission fee as prescribed by the University from time to time; if Dean/Principal is satisfied that re-admission of the student will not fall short of requisite percentage of the attendance.

(iii) If a student is re-admitted, all his previous records shall be revived under the current structure, regulations and schedule of fees.

25. Other Provisions:

i. Nothing in the Ordinance shall debar the University from amending the Ordinance and the same shall be applicable to all the students whether old or new.

ii. Any other provision not contained in the Ordinance shall be governed by the rules and regulations framed by the University from time to time.

iii. In case of any dispute, the Vice-Chancellor will be competent authority to interpret the rules and his interpretation shall be final.

M.Sc. Mathematics
Syllabus (2020-21)
Program Structure under Choice Based Credit System (CBCS)

SEMESTER	COURSE CODE	COURSENAME	L	T	P	Contact hours/ week	Credits	Max. Marks	Formative Assessment	Summative Assessment
I	**Core Courses (CC)**									
	17070101	Real Analysis	3	0	0	3	3	100	40	60
	17070102	Measure Theory	3	0	0	3	3	100	40	60
	17070103	Linear Algebra	3	0	0	3	3	100	40	60
	17070104	Complex Analysis	3	0	0	3	3	100	40	60
	17070105	Ordinary Differential Equations	3	0	0	3	3	100	40	60
	17070106	Ordinary Differential Equations Lab	0	0	4	4	2	100	60	40
	Ability Enhancement Compulsory Course (AECC)									
	17070107	Professional Ethics and Human Values	2	0	0	2	2	100	40	60
	Skill Enhancement Course									
	17070108	Introduction to MATLAB	0	0	4	4	2	100	60	40
Total Credits			**17**	**0**	**8**	**25**	**21**	**800**	**360**	**440**
II	**Core Courses**									
	17070201	Abstract Algebra	3	0	0	3	3	100	40	60
	17070202	Metric Spaces	3	0	0	3	3	100	40	60
	17070203	Topology	3	0	0	3	3	100	40	60
	17070204	Functional Analysis	3	0	0	3	3	100	40	60
	17070205	Probability and Statistics	3	0	0	3	3	100	40	60
	17070206	Probability and Statistics Lab	0	0	4	4	2	100	60	40
	Ability Enhancement Compulsory Course (AECC)									
	17070207	Research Methodology	2	0	0	2	2	100	40	60
	Skill Enhancement Course									
	17070208	Programming with Python	0	0	4	4	2	100	60	40
Total Credits			**17**	**0**	**8**	**25**	**21**	**800**	**360**	**440**
	17070209	**Summer Training(4/6 weeks)**	**-**	**-**	**-**	**-**	**4**	**200**	**100**	**100**
III	**Specialization**									
	Discipline Specific Elective Courses(DSEC)(Four Theory courses and Two Lab Courses)									
		DSEC 1	3	0	0	3	3	100	40	60
		DSEC 2	3	0	0	3	3	100	40	60
		DSEC 3	3	0	0	3	3	100	40	60
		DSEC 4	3	0	0	3	3	100	40	60
		DSEC 3 Lab	0	0	4	4	2	100	60	40
		DSEC 4 Lab	0	0	4	4	2	100	60	40
	Open Elective Course (From University Basket)(Common for all the specializations)									
	17070316	OEC	3	0	0	3	3	100	40	60
	Skill Enhancement Course									
	17070315	Introduction to LaTeX	0	0	4	2	1	100	60	40
Total Credits			**17**	**0**	**8**	**25**	**20**	**800**	**380**	**420**
IV	**Research Training(Mandatory)(Common for all the specializations)**									
	17070401	Dissertation / Industry project	0	0	20	20	20	400	200	200
Total Credits			**0**	**0**	**20**	**20**	**20**	**400**	**200**	**200**
Grand Total			**51**	**0**	**44**	**95**	**86**	**3000**	**1400**	**1600**

Semester (Credits)	Core Courses	DSE Courses	SE Courses	AEC Courses	Research Training	Open Elective	Total
I	17	-	2	2	-	-	**21**
II	17	-	2	2	-	-	**21**
III	-	16	1	-	-	3	**20**
IV	-		-	-	20	-	**20**
Total	**34**	**16**	**5**	**4**	**20**	**3**	**82**
Summer Training (4/6 Weeks) after Second Semester							**04**
Online courses from SWAYAM (Sem – I to Sem – III) Maximum							**09**
Grand Total							**95**
Minimum Credits for award of degree							**85**

Category	Credits	%
Core Course(CC)	34	35
Discipline Specific Elective Course(DSEC)	16	17
Skill Enhancement Course (SEC)	5	6
Ability Enhancement Compulsory Course (AECC)	4	4
Research Training	20	21
Open Elective	3	3
Summer Training after second semester	4	4
Online courses from SWAYAM (Sem – I to Sem – III)	9	10
Total	95	100

Choices for DSEC 1		
S. No.	**Course Code**	**Subject**
1	17070301	Discrete Mathematics
2	17070302	Mathematical Modelling and Simulation
3	17070303	Differential Geometry
Choices for DSEC 2		
1	17070304	Special Functions
2	17070305	Fuzzy Sets and its Applications
3	17070306	Fluid Dynamics
Choices for DSEC 3		
1	17070307	Numerical Analysis and its Applications
	17070308	Numerical Analysis and its Applications Lab
2	17070309	Cryptography
	17070310	Cryptography Lab
Choices for DSEC 4		
1	17070311	Mathematical Programming
	17070312	Mathematical Programming Lab
2	17070313	Integral Equations
	17070314	Integral Equations Lab

Name of the Faculty : Faculty of Science

Name of the Program : M.Sc.(Mathematics), 2021

S. No.	Semester/ Year	Course Code	Nomenclature							Theory		Theory (Internal)					Practical				Practical (Internal)								Whether to be offered under CBCS (Yes/No)	Scheme of Examinations (Theory+Internal+Practical+Oral/ Theory+Internal+Practical/ Theory+Practical
										Max	Pass	Midterm	Assignment	Professional Activities	Max	Pass	Demonstration/Conduct/Presentation	Viva-voce	Max	Pass	Attendance & Regularity in Lab Work	Project/Laboratory Work Report	Midterm Oral Examination/Assessment	Conduct/Demonstration	Max	Pass	Overall Maximum marks	Overall Pass Marks		
1	I / I	17070101	Real Analysis	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
2		17070102	Measure Theory	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
3		17070103	Linear Algebra	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
4		17070104	Complex Analysis	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
5		17070105	Ordinary Differential Equations	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
6		17070106	Ordinary Differential Equations Lab	Practical	Core	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
7		17070107	Professional Ethics and Human Values	Theory	AECC	2	0	0	2	60	24	20	10	10	40	16												100	40	No	Theory+Internal
8		17070108	Introduction to MATLAB	Practical	SEC	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
9	II/I	17070201	Abstract Algebra	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
10		17070202	Metric Spaces	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
11		17070203	Topology	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
12		17070204	Functional Analysis	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
13		17070205	Probability and Statistics	Theory	Core	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
14		17070206	Probability and Statistics Lab	Practical	Core	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
15		17070207	Research Methodology and Technical Writing	Theory	AECC	2	0	0	2	60	24	20	10	10	40	16												100	40	No	Theory+Internal
16		17070208	Programming with Python	Practical	SEC	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
17		17070209	Summer Training	Practical		0	0	0	4								40	40	80	32	20	20	20	60	120	48	200	80	No	Internal+Practical
18	III/II	17070301	Discrete Mathematics	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
19		17070302	Mathematical Modelling and Simulation	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
20		17070303	Differential Geometry	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
21		17070304	Special Functions	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
22		17070305	Fuzzy Sets and its Applications	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
23		17070306	Fluid Dynamics	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
24		17070307	Numerical Analysis and its Applications	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
25		17070308	Numerical Analysis and its Applications Lab	Practical	DSEC	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
26		17070309	Cryptography	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
27		17070310	Cryptography Lab	Practical	DSEC	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
28		17070311	Mathematical Programming	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
29		17070312	Mathematical Programming Lab	Practical	DSEC	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
30		17070313	Integral Equations	Theory	DSEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
31		17070314	Integral Equations Lab	Practical	DSEC	0	0	4	2								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
32		17070315	Introduction to LaTeX	Practical	SEC	0	0	4	1								20	20	40	16	10	10	10	30	60	24	100	40	No	Internal+Practical
33		17070316	Open Elective Course (From University Basket)	Theory	OEC	3	0	0	3	60	24	20	10	10	40	16												100	40	No	Theory+Internal
34	IV/II	17070401	Project work	Practical	RT	0	0	0	20								80	80	160	64	40	40	40	120	240	96	400	160	No	Theory+Internal
35			**Online Courses during 1st, 2nd and 3rd semesters***						9																					

***4 week course- 1 credit, 8 week course- 2 credits, 12 weeks course- 3 credits**
Every semester a student may opt for either:
One, 12 week course or
One, 4 week course & One, 8 week course or
Three, 4 week courses

1. Name of the Department: Mathematics						
2. Course Name	Real Analysis	**L**	**T**		**P**	
3. Course Code	17070101	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

This course covers some fundamental topics of mathematical analysis. In this course the students will be taught Riemann Stieltjes Integral, Uniform convergence of sequences and series of functions, and functions of several variables.

9. Course Objectives:

The objective of this course is to introduce some fundamental topics of mathematical analysis like Riemann Stieltjes integral, uniform convergence of sequences and series of functions, and functions of several variables which are directly relevant in some other papers of M.Sc. Mathematics course.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To demonstrate the knowledge of Riemann Stieltjes integral, behavior of sequences and series of functions.
2. To enable for solving real world problems in scientific domains using Weierstrass approximation theorem.
3. To apply concepts of mathematical analysis like power series, Fourier series, gamma functions etc.
4. To apply fixed point theorems for solving research based problems such as differential equations, Integral equations and fractional calculus.

11. Unit wise detailed content

Unit-1	**Number of lectures = 08**	**Title of the unit: Riemann Stieltjes Integral**

Definition and existence of Riemann Stieltjes integral, properties of the integral, reduction of Riemann Stieltjes integral to ordinary Riemann integral, change of variable, integration and differentiation, Fundamental theorem of integral calculus, integration by parts, first and second mean value theorems for Riemann Stieltjes integrals, integration of vector-valued functions.

Unit – 2	**Number of lectures = 12**	**Title of the unit: Sequences and Series of Functions**

Point wise and uniform convergence of sequences of functions, Cauchy criterion for uniform convergence, Uniform convergence and continuity, uniform convergence and Riemann integration, uniform convergence and differentiation, convergence and uniform convergence of series of functions, Weierstrass M-test, Abel's test, integration and differentiation of series of functions, existence of a continuous nowhere differentiable function, the Weierstrass approximation theorem.

Unit – 3	**Number of lectures = 12**	**Title of the unit: Functions of several variables**

Functions of several variables: Linear transformations, the space of linear transformations on R_n to R_m as a metric space, open sets, continuity, derivative in an open subset of R_n, chain rule, partial derivatives, directional derivatives, continuously differentiable mappings, necessary and sufficient conditions for a mapping to be continuously differentiable, contractions, the contraction principle (fixed point theorem), the inverse function theorem, the implicit function theorem.

Unit – 4	Number of lectures = 08	Title of the unit: Power Series
Power Series: Uniqueness theorem for power series, Abel's and Tauber's theorem, Taylor's theorem, Exponential & Logarithmic functions, Trigonometric functions, Fourier series, Gamma function.		
12. Brief Description of self learning / E-learning component		
https://youtu.be/LUKfrjpDHTk https://youtu.be/2iXpgCdQDuM https://youtu.be/ZZUYzTsBk-0		
13. Books Recommended		
1. Principles of Mathematical Analysis' by Walter Rudin (3rd Edition) McGraw-Hill, 1976 2. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985. 3. S.C. Malik and SavitaArora, Mathematical Analysis, New Age International Limited, New Delhi,4th Edition 2010. 4. D. Somasundaram and B. Choudhary : A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997. 5. Gabriel Klambauer, Mathematical Analysis, Marcel Dekkar, Inc. New York, 1975.		

1. Name of the Department: Mathematics						
2. Course Name	Measure Theory	**L**	**T**		**P**	
3. Course Code	17070102	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

Measure theory and theory of the integral developed by Lebesgue at the beginning of the last century found numerous applications in other branches of pure and applied mathematics, for example in the theory of (partial) differential equations, functional analysis and fractal geometry; it is used to give mathematical foundation to probability theory and statistics, and on the real line it gives a natural extension of the Riemann integral which allows for better understanding of the fundamental relations between differentiation and integration. This course provides the essential foundations of this important aspect of mathematical analysis.

9. Course Objectives:

Students will be able to understand :

1. Studying the theory of Lebesgue measure through the abstract theory of Lebesgue-Stieltjes measures.
2. Studying the differences between the Riemann integral and the Lebesgue integral as a basis for further study of function spaces.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the basic concepts of measure, Lebesgue integral and theirs properties.
2. To analyze the mathematical problem using the Lebesgue integral and understand the applications of Lp-spaces in probability theory.
3. To describe the construction of product measure and to apply Fubini's theorem in real life problems.
4. To understand the basic of Regular Borel measures, Integration of continuous functions with compact support, Riesz-Markoff's theorem to describe research based problems.

11. Unit wise detailed content

Unit-1	**Number of lectures = 8**	**Title of the unit: Measurable Functions**

Measures, some properties of measures, outer measures, extension of measures, uniqueness of extension, completion of a measure, the LUB of an increasingly directed family of measures .Measurable functions, combinations of measurable functions, limits of measurable functions, localization of measurability, simple functions.

Unit – 2	**Number of lectures = 12**	**Title of the unit: Measure Spaces**

Measure spaces, almost everywhere convergence, fundamental almost everywhere, convergence in measure, fundamental in measure, almost uniform convergence, Egoroff's theorem, Riesz-Weyltheorem, Integration with respect to a measure: Integrable simple functions, non-negative integrable functions, integrable functions, indefinite integrals, the monotone convergence theorem, mean convergence.

Unit – 3	Number of lectures = 12	Title of the unit: Product and signed measures
Product Measures: Rectangles, Cartesian product of two measurable spaces, measurable rectangle, sections, the product of two finite measure spaces, the product of any two measure spaces, product of two σ - finite measure spaces; iterated integrals, Fubini's theorem, a partial converse to the Fubini's theorem, Signed Measures: Absolute continuity, finite singed measure, contractions of a finite signed measure, purely positive and purely negative sets, comparison of finite measures, Lebesgue decomposition theorem, a preliminary Radon-Nikodym theorem, Hahn decomposition, Jordan decomposition, upper variation, lower variation, total variation.		
Unit – 4	**Number of lectures = 8**	**Title of the unit: Measurable Integration**
Integration over locally compact spaces: continuous functions with compact support, Gδ 's and Fσ's, Baire sets, Baire function, Baire-sandwich theorem, Baire measure, Borel sets, Regularity of Baire measures, Regular Borel measures, Integration of continuous functions with compact support, Riesz-Markoff's theorem.		

12. Brief Description of self learning / E-learning component

Learners are offered e-learning courseware (also called Web-based training (WBT)), which can be complemented by supplemental resources and assessments. Courseware is usually housed on a Web server, and learners can access it from an online learning platform or on CD-ROM

http://www.nptelvideos.com/course.php?id=731
https://swayam.gov.in/course/3790-measure-theory

13. Books Recommended

1. H.L.Royden: Real Analysis, Prentice Hall of India, 3rd Edition, 1988.
2. G.de Barra: Measure Theory and Integration, Wiley Eastern Ltd.,1981.
3. P.R.Halmos: Measure Theory, Van Nostrand, Princeton, 1950.
4. I.K.Rana: An Introduction to Measure and Integration, Narosa Publishing House, Delhi, 1997.
5. R.G.Bartle: The Elements of Integration, John Wiley and Sons, Inc. New York, 196

1. Name of the Department: Mathematics						
2. Course Name	Linear Algebra	**L**	**T**		**P**	
3. Course Code	17070103	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 40	**Tutorials = 0**	**Practical = 0**

8. Course Description:

An introduction to linear algebra and how it can be used, including basic mathematical proofs. Topics include systems of equations, vectors, matrices, orthogonality, subspaces, and the eigen value problem

9. Course Objectives:

Problems in linear algebra arise in a wide variety of scientific and engineering applications including the design of structures, the analysis of electrical networks, and the modeling of chemical processes. This course will cover the analysis and implementation of algorithms used to solve linear algebra problems in practice. This course will enable students to acquire further skills in the techniques of linear algebra, as well as understanding of the principles underlying the subject.

10. Course Outcomes (Cos):

By the end of this course, students should be able:

1. To demonstrate about basic knowledge of vector space such as linear space, Subspace, linear dependence and linear transformations.
2. To apply linear transformations & theirs properties for solving mathematical and computational problems such as computer graphics
3. To analyze mathematical problems using Jordan canonical form, spectral theorem and Gram-Schmidt orthonormalization.
4. To discuss well-known research problems regarding Bilinear transformations, Inner product and diagonalization.

11. Unit wise detailed content

Unit – 1	**Number of lectures = 8**	**Title of the unit: Matrices, Determinants and Vector spaces**

Matrices: Elementary matrices, invertible matrices, Gauss-Jordon method, determinant, Systems of linear equations and Cramer's Rule. Vector spaces: Fields, Vector spaces over a field, subspaces, Linear independence and dependence, existence of basis, coordinates, dimension.

Unit-2	**Number of lectures = 12**	**Title of the unit: Linear Transformation and Inner Product Spaces**

Linear Transformations: Rank Nullity Theorem, isomorphism, matrix representation of linear transformation, change of basis, similar matrices, linear functional and dual space. Inner product spaces: Cauchy-Schwarz's inequality, Gram-Schmidt orthonormalization, orthonormal basis, orthogonal projection, projection theorem, four fundamental subspaces and their relations (relation between null space and row space; relation between null space of the transpose and the column space).

Unit – 3	Number of lectures = 12	Title of the unit: Diagonalization
Diagonalization: Eigenvalues and eigenvectors, diagonalizability, Invariant subspaces , adjoint of an operator, normal, unitary and self adjoint operators, Schur's Lemma, diagonalization of normal matrices, spectral decompositions and spectral theorem, applications of spectral theorem, Cayley-Hamilton theorem, primary decomposition theorem, Jordon canonical form, minimal polynomials,		
Unit – 4	**Number of lectures = 8**	**Title of the unit:Introduction to Bilinear and Quadratic Forms.**
Introduction to bilinear and Quadratic forms: Bilinear and quadratic forms, Sylvester's law of inertia. Some applications: Lagrange interpolation, LU,QR and SVD decompositions, least square solutions, least square fittings, pseudo inverses.		

12. Brief Description of self learning / E-learning component

1. http://home.iitk.ac.in/~arlal/book/nptel/pdf/booklinear.html
2. http://www.maths.qmul.ac.uk/~pjc/notes/linalg.pdf
3. http://www.mathe2.uni-bayreuth.de/stoll/lecture-notes/LinearAlgebraI.pdf
4. https://www.cs.cornell.edu/courses/cs485/2006sp/LinAlg_Complete.pdf

13. Books Recommended:

1. Kenneth Hoffman and Ray Kunze: Linear Algebra, PHI publication.
2. Gilbert Strang: Linear Algebra and Its Applications, 4th edition.
3. Sheldon Axler: Linear Algebra Done Right, UTM, Springer.

1. Name of the Department: Mathematics						
2. Course Name	Complex Analysis	**L**	**T**		**P**	
3. Course Code	17070104	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**		**Practical =0**		

8. Course Description:

The subject gives an introduction to the theory of functions of complex variable. Discuss in the course are analytic and harmonic functions and their properties, power series and Laurent series, isolated singularities, Cauchy's integral theorem and residue calculus.

9. Course Objectives:

Students will be equipped with the understanding of the fundamental concepts of complex analysis. In particular, students will acquire the skill of contour integration to evaluate complicated real integrals via residue calculus.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the basic knowledge of analycity of complex valued functions, Riemann Zeta function, Schwarz Reflection principle and theirs properties.
2. To evaluate definite integrals using Maximum modulus principle, Minimum modulus principle and Residue theorem.
3. To apply Taylor and Laurent series to expend complex valued functions and theirs applications to evaluate the residue.
4. To solve research problems of algebraic geometry, number theory and many problems arising in solid and fluid mechanics.

11. Unit wise detailed content

Unit-1	**Number of lectures = 12**	**Title of the unit: Function of Complex Variable**

Analytic functions and their properties, Cauchy-Riemann equations in Cartesian and polar coordinates. Power series, Radius of convergence, Differentiability of sum function of a power series, Branches of many valued functions with special reference to arg z, log z and z^a , Complex integration, Cauchy theorem, Cauchy's integral formula, Poisson's integral formula , Higher order derivatives, Complex integral as a function of its upper limit, Morera's theorem ,Cauchy's inequality, Liouville's theorem, The fundamental theorem of algebra., Taylor's theorem.

Unit – 2	**Number of lectures = 8**	**Title of the unit: Zeros of Analytic Functions**

Zeros of an analytic function, Laurent's series, Isolated singularities, Casporati-Weierstress theorem, Limit point of zeros and poles, Maximum modulus principle, Minimum modulus principle, Schwarz lemma, Meromorphic functions, The argument principle, Rouche's theorem, Inverse function theorem.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Calculation of Residues**

Calculation of residues, Cauchy's residue theorem, Evaluation of integrals, Bilinear transformations, theirproperties and classifications, Definitions and examples of Conformal mappings, Space of analytic functions and their completeness, Hurwitz's theorem, Montel's theorem, Riemann mapping theorem.

Unit – 4	**Number of lectures = 10**	**Title of the unit: Integral Functions.**

Integral Functions, Factorization of an integral function, Weierstrass' factorization theorem, Factorization of sine function, Gamma function and its properties, Stirling's formula, Integral version of gamma function,Riemann Zeta function, Riemann' functional equation, Schwarz Reflection principle.

12. Brief Description of self learning / E-learning component

www.youtube.com/watch?v=yV_v6zxADgY&index=10&list=PLbMVogVj5nJS_i8vfVWJG16mPcoEKMuWT

https://nptel.ac.in/courses/111107056/

https://nptel.ac.in/courses/111103070/

13. Books Recommended

1. H.A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. J.B. Conway, Functions of one Complex variable, Springer-Verlag, International student-Edition, Narosa Publishing House, 1980.
3. Liang-shin Hann&Bernand Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
4. E.T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London.
5. E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London.
6. L.V. Ahlfors, Complex Analysis, McGraw Hill, 1979.

1. Name of the Department: Mathematics						
2. Course Name	Ordinary Differential Equations (ODEs)	**L**	**T**		**P**	
3. Course Code	17070105	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

Linear differential equations of nth order, fundamental sets of solutions, Wronskian, adjoint – self – adjointlinear operator, Green's theorem, Adjoint equations, Solutions to nth order non-homogeneous linear equations-Variation of parameters, Fundamental existence and uniqueness theorem, Sturm-Liouville problems- Orthogonality of eigenfunctions, Power series solution of linear differential equations, matrix method, Linear and Non-linear autonomous system of equations - Phase plane - Critical points – stability.

9. Course Objectives:

The general purpose of this course is to provide an understanding of basic and advanced methods for solving differential equations.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To prepare scientific data and try to find numerical explanations using suitable methods related to advanced differential equations.
2. To solve basic problems, to move flexibly between the representations using different differential equations methods in concrete situations.
3. To apply different methods as Bernoulli Differential Equations, Euler's methods and Laplace methods.
4. To develop differential equation based methods tor elate the positive effect of environment, epistemological and motivational beliefs.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the Unit: Basics of Linear differential equations**

Linear differential equations of nth order, fundamental sets of solutions, Wronskian –Abel's identity, theorems on linear dependence of solutions, adjoint, self-adjointlinear operator, Green's theorem, Adjoint equations, the nth order non-homogeneous linear equations- Variation of parameters - zeros of solutions – comparison and separation theorems.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Existence- Uniqueness of solutions for ODEs**

Fundamental existence and uniqueness theorem of solution of ODEs, Dependence of solutions on initial conditions, existence and uniqueness theorem for higher order and system of differential equations – Eigenvalue problems – Sturm-Liouville problems- Orthogonality of eigenfunctions - Eigenfunction expansion in a series of orthonormal functions- Green's function method.

Unit – 3	**Number of lectures = 12**	**Title of the unit: Series Solution of ODEs**

Power series solution of linear differential equations- ordinary and singular points of differential equations, Classification into regular and irregular singular points; Series solution about an ordinary point and a regular singular point – Frobenius method- Hermite, Laguerre, Chebyshev and Gauss

Hypergeometric equations and their general solutions. Generating function, Recurrence relations, Rodrigue's formula-Orthogonality properties. Behaviour of solution at irregular singular points and the point at infinity.		
Unit – 4	**Number of lectures = 08**	**Title of the unit: Stability analysis of solution to ODEs**
Linear system of homogeneous and non-homogeneous equations (matrix method) Linear and Non-linear autonomous system of equations - Phase plane - Critical points – stability - Liapunov direct method		
12. Brief Description of self learning / E-learning component		
http://nptel.ac.in/courses/111108081/ https://ocw.mit.edu/courses/mathematics/18-03-differential-equations-spring-2010/video-lectures/		
13. Books Recommended		
1. G.F. Simmons: Differential Equations, TMH Edition, New Delhi, 1974. 2. M.S.P. Eastham: Theory of ordinary differential equations, Van Nostrand, London, 1970. 3. S.L. Ross: Differential equations (3rd edition), John Wiley & Sons, NewYork, 1984. 4. E.D. Rainville and P.E. Bedient: Elementary Differential Equations, McGraw Hill, NewYork, 1969. 5. E.A. Coddington and N. Levinson: Theory of ordinary differential equations, McGraw Hill, 1955. 6. A.C. King, J. Billingham and S.R. Otto: 'Differential equations', Cambridge University Press, 2006.		

1. Name of the Department: Mathematics						
2. Course Name	Ordinary Differential Equations Lab	**L**	**T**		**P**	
3. Course Code	17070106	0	0		4	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 0	**Tutorials = 0**	**Practical = 52**

8. Course Description:

This course is designed to emphasize the knowledge of differential equations. Emphasis is placed on different forms of linear and non-linear differential equations. Upon completion, students should be able to write the programs in MATLAB and other software.

9. Course Objectives:

1. Give an account of basic concepts and definitions for differential equations.
2. Use methods for obtaining exact solutions of linear homogeneous and non-homogeneous differential equations.
3. Describe some simple numerical solution techniques and be familiar with mathematical software for differential equations.
4. Use elementary methods for linear systems of differential equations.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To provide basic concepts and definitions for differential equations.
2. To use software to solve differential equations individually and as a system of equation in parallel with analytical mathematics trends.
3. To apply different software tools for obtain the significant result of large data set.
4. To obtain better result in engineering systems for different applied problems namely thermal system, mechanical system and others engineering applications.

11. List of Practical's (using any one from C, C++ , MATLAB, Maple)

- To solve differential equation by basic methods with and without initial conditions.
- To solve first order Bernoulli equations
- To solve Non-linear differential equations with initial conditions
- To solve second order ODE with initial conditions
- To solve nth order non-homogeneous linear equations
- To solve Eigenvalue problems
- To solve Sturm-Liouville problems
- To Solve Hermite, Laguerre, Chebyshev and Gauss Hypergeometric equations
- To find Power series solution of linear differential equations
- Solution by Euler's and modified Euler's methods of ODEs

• R.K method to solve system of ODEs.
12. Books Recommended
1. Gurpreet Singh Tuteja, "Practical Mathematics, International BOOK house Pvt Ltd. 2. https://www.mathworks.com/help/symbolic/solve-a-single-differential-equation.html 3. https://in.mathworks.com/help/symbolic/solve-a-system-of-differential-equations.html 4. https://www.mathworks.com/help/matlab/math/choose-an-ode-solver.html 5. http://www.math.tamu.edu/undergraduate/research/REU/comp/matode.pdf

1. Name of the Department :Mathematics						
2. Course Name	Professional ethics and human value	**L**		**T**	**P**	
3. Course Code	17070107	2		0	0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC (✓)**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 26		**Tutorials = 0**		**Practical = 0**		

8. Course Description:

This course provides students with the knowledge of ethics in professional life. Some of the examples from history and day to day life will make the students more responsible towards their profession, society and family.

9. Course Objectives:

1. To develop ethical and human values in students
2. To develop the responsibility in students at professional and societal levels.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To able to take strong decisions and perform their duties responsibly as on professional.
2. To learn the moral issues and problems in engineering and to find the solution of those problems.
3. To learn the need for professional ethics, codes of ethics and roles, concept of safety, risk assessment.
4. To gain exposure to Environment Ethics & computer ethics; know their responsibilities and rights.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Ethics and Human Values**

Definition, History and Development of Ethics, Universal declaration on Bioethics, ,Theories related to Bioethics: Utilitarian theory, Deontological theory and Communication theory, Human Rights and Values : Autonomy, Consent, Equality, Confidentiality, Vulnerability and Personal IntegrityEnvironmental Ethics, Animal ethics

Unit-1	**Number of lectures = 10**	**Title of the unit: Human Values**

Human Rights and Values : Autonomy, Consent, Equality, Confidentiality, Vulnerability and Personal IntegrityEnvironmental Ethics, Animal ethics.

Unit –3	**Number of lectures = 10**	**Title of the unit: Professional Ethics & Responsibility**

Need and Importance of professional ethics, Goals, Dignity of Labour, IRB & its functions, Authorship

Religious and Cultural Values, Importance of a Family, Guidance to youngsters, Gender Equality

Unit –4	**Number of lectures = 10**	**Title of the unit: Responsibility**

Responsibilities towards Safety and Risk, Voluntary v/sIn voluntary Risk, Designing/Research for Safety – Risk, Benefit Analysis, Accidents, Disaster ethics, Ethics in Media and Technology, Research Ethics,

Intellectual Property Rights.
12. Brief Description of self learning / E-learning component
1. https://www.youtube.com/watch?v=cFOZplkRqsk&authuser=2 2. https://www.youtube.com/watch?v=HJk1Eodmf9A&authuser=2 3. https://www.youtube.com/watch?v=Fqt7m8LH5GY&authuser=2 4. https://youtu.be/2VYF_t51FyE 5. https://youtu.be/hjzA_rZG-bU
13. Books Recommended
1. Professional Ethics and Morals by Prof. A. R. Aryasri, Dharanikota Suyodhana – Maruthi Publications. 2. Professional Ethics and Human Values by A. Alavudeen, R.Kalil Rahman and M. Jayakumaran – University Science Press. 3. Professional Ethics and Human Values by Prof. D. R. Kiran-Tata McGraw-Hill – 2013

1. Name of the Department :Mathematics						
2. Course Name	Introduction to MATLAB	**L**		**T**	**P**	
3. Course Code	17070108	0		0	2	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. Pre-requisite 6. (if any)	NA	**7. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 0		**Tutorials = 0**		**Practical = 26**		

8. Course Description:

The course provides a gentle introduction to the MATLAB computing environment. It gives students a basic understanding of MATLAB, including popular toolboxes. The course consists of interactive lectures and sample MATLAB problems given as assignments and discussed in class. Concepts covered include basic use, graphical representations and tips for designing and implementing MATLAB code.

9. Course Objectives:

The course provides a gentle introduction to the MATLAB computing environment, and is intended for beginning users and those looking for a review. It is designed to give students a basic understanding of MATLAB, including popular toolboxes. The course consists of interactive lectures and sample MATLAB problems given as assignments and discussed in class. No prior programming experience or knowledge of MATLAB is assumed. Concepts covered include basic use, graphical representations and tips for designing and implementing MATLAB code.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To demonstrate fundamental knowledge of MATLAB.
2. To use MATLAB effectively to analyze mathematical and analytical problems in various scientific domains.
3. To apply MATLAB to solve several research based problems such as mathematical modeling, computational fluid dynamics.
4. To create and control simple plot and user-interface graphics objects in MATLAB.

11. Unit wise detailed content

Unit-1	**Number of lectures = 13**	**Title of the unit: Acquaintance with MATLAB**

Introduction to MATLAB, Standard MATLAB windows (Command Window, Figure Window, Editor Window, help window), The semicolon (;), The clc command, Using MATLAB as calculator, Display formats, Elementary math built in functions, The zeroes, ones and eye commands, The transpose operators, Using a colon, Adding elements to existing variables, Deleting elements, Creating arrays (one dimensional & two dimensional), Built in functions for handling arrays, Array multiplication, Saving a function file, Using a user-defined function, Examples of simple user-defined Functions, Comparison between script files and function files, Anonymous and inline functions, Anonymous functions, Inline functions, Using function handles for passing a function into a function, Using a function name for passing a function into a function, Sub-functions nested functions.

Unit –2	**Number of lectures = 13**	**Title of the unit: Basic operations in MATLAB**

Inverse of a matrix, Solving three linear equations (array division), Element by element operations, Built in

function for analyzing arrays, Generation of random numbers, Creating and saving a script files, output commands, User-defined functions and function files, Creating a Function File, Structure of a function file, Function definition, Input and output arguments, Function body, Local and global variables, Programming in MATLAB, Relational and logical operators, The break and continue commands, Two dimension and three dimensional plots, Line plots, Mesh and surface plots, Plots with special graphics, Solving an equation with one variable
12. Brief Description of self learning / E-learning component
1. https://in.mathworks.com/learn/tutorials/matlab-onramp.html 2. https://www.tutorialspoint.com/matlab/index.htm
13. Books Recommended
1. Amos Gilat: MATLAB-An Introduction and its Applications, Wiley India Edition. 2. E. Balagurusamy: Programming in ANSI C, McGraw Hill Education, 8th Ed.

1. Name of the Department: Mathematics						
2. Course Name	Abstract Algebra	**L**	**T**		**P**	
3. Course Code	17070201	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**		**Practical = 0**		

8. Course Description:

This Course covers properties of integer sets, groups, permutation groups, homomorphism and isomorphism of groups. A brief introduction to Ring theory and finite fields is given.

9. Course Objectives:

This course aims provide an introductory approach to the subject of Algebra, which is one of the basic pillar of modern Mathematics. This course gives students a good mathematical maturity and enables them to develop abstract thinking and mathematical skills.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the basic knowledge of group theory, ring theory and modules.
2. To enable for solving real life problems using group theory in various scientific domains such as cyber security and cryptography.
3. To analyze several mathematical problems through solvable group.
4. To solve many research problems from Integral Domains, Artenian Modules and Noetherian Modules.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of Unit: Groups& Normal subgroups**

Groups, symmetric groups, Cayley's theorem, Normal subgroups, centre of a group, quotient groups, Fundamental theorem of homomorphism, Class equation of groups, Cauchy's theorems for abelian and non-abelian groups, Sylow's Theorems for abelian and non-abelian groups, Applications of Sylow's Theorem.

Unit – 2	**Number of lectures = 10**	**Title of Unit: Solvable Groups**

Solvable groups, Maximal subgroups, composition Series of a group, Jordan Holder Theorem, nilpotent groups, direct product of groups, structure theorem for finite abelian groups.

Unit – 3	**Number of lectures = 10**	**Title of Unit: Ring Theory**

Rings, homomorphism of rings, ideals, maximal ideals, quotient rings, Integral Domains, Fields, Euclidean domains, PID, UFD, Polynomial rings, polynomial over the rational fields, Irreducibility criterion, Gauss lemma, Eisenstein criterion for irreducibility.

Unit – 4	**Number of lectures = 10**	**Title of Unit: Modules**

Modules, Definition and examples, Sub Modules, Direct sum decomposition, Free modules, Quotient modules, Simple modules, Modules over Principle ideal domains, Modules with chain conditions, Artenian Modules, Noetherian Modules, Hilbert's basis theorem.

12. Brief Description of self-learning / E-learning component

1. https://www.youtube.com/watch?v=g7L_r6zw4-c
2. https://www.youtube.com/watch?v=GJtNLiG4Hv8
3. https://www.youtube.com/watch?v=DSxOCdpmeBI

13. Books Recommended

1. I.N.Herstein, I.N. Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal. Basic Abstract Algebra. 2nd ed. Cambridge University Press, Indian Edition, 1997.
3. P.M. Cohn. Algebra. Vols. I, II & III. John Wiley, 1991.
4. N. Jacobson. Basic Algebra. Vol. I &II.Hindustan Publishing Company.
5. S. Lang. Algebra. 3rd ed. Addison-Wesley, 1993.
6. I.S. Luther and I.B.S.Passi, Algebra. Vol. I – II. NarosaPublishing House, 1990; 1996.
7. D.S. Malik, J.N. Mordenson, and M.K. Sen. Fundamentals of Abstract Algebra. International ed. McGraw-Hill, 1997.
8. VivekSahaiandVikasBisht. Algebra. Narosa Publishing House , 1999

1. Name of the Department: Mathematics						
2. Course Name	Metric Spaces	**L**	**T**		**P**	
3. Course Code	17070202	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

This course includes basics of metric spaces, its properties, open and closed sets with respect to metric defined, sequences and their convergence in metric spaces, abstract properties: connected and compactness, hiene-borel theorem, homeomorphism and isometry of metric spaces

9. Course Objectives:

The main objective of this course is to familiarize students with the basic notions of metric spaces and understand it in a more general setting as an abstraction to real analysis

10. Course Outcomes (Cos):

By the end of this course, students should be able:

1. To understand the basic notion of metric space, complete metric space and compact metric space.
2. To analyze the properties in comparison to real valued functions and functions in metric spaces.
3. To understand the concepts of sequence and their convergence in metric spaces.
4. To apply the metric fixed point theorems to solve the integral and differential type equations.

11. Unit wise detailed content

Unit – 1	**Number of lectures = 10**	**Title of the unit: Introduction to Metric Spaces**

Definition and examples of metric spaces, Bounded and unbounded metric spaces, Distance between sets, Diameter of a set, Open and closed balls, Interior points and interior of a set, Open set, Neighbourhood of a point, Limit point of a set, Closure of a set, Closed set, Boundary points and boundary of a set, Exterior points and exterior of a set, Subspace of a metric space..

Unit-2	**Number of lectures = 10**	**Title of the unit: Sequences in Metric Spaces**

Sequences and sub-sequences in a metric space, Convergent and Cauchy sequences, Complete metric spaces, Relation between completeness and closedness, Cantor Intersection Theorem, Completion Theorem, Dense sets, Separable spaces, Nowhere dense sets, Categories and Baire Category Theorem.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Connectedness and Compactness**

Cover of a metric space, Compact metric spaces, Compact sets and their criterion, Properties of compact sets, Relation between compactness, completeness and closedness, Finite Intersection property, Bolzano-Weierstrass property, Sequential compactness, Totally bounded spaces; Separated sets, Connected and disconnected metric spaces, Properties of connected sets.

Unit – 4	Number of lectures = 10	Title of the unit: Function on Metric Spaces
Continuous functions, Characterizations of Continuous functions, Continuous functions on compact andconnected spaces, Uniform continuous functions, Homeomorphism and Isometry.		

12. Brief Description of self learning / E-learning component

1. https://www.youtube.com/watch?v=Af03P1xVNSs
2. https://www.youtube.com/watch?v=Ry07_mO-iac
3. https://www.youtube.com/watch?v=1DghwIIir-U

13. Books Recommended:

1. Q. H. Ansari: Metric Spaces Including Fixed Point Theory and Set-valued Maps, Narosa Publishing House, New Delhi. 2010.

2. E. T. Copson: Metric spaces, Cambridge University Press, 1968.

3. M. O. Searcoid: Metric spaces, Springer, 2007.

4. S. Kumaresan: Topology of Metric Spaces, Narosa Publishing House, 2nd Ed, 2011.

1. Name of the Department: Mathematics						
2. Course Name	Topology	**L**	**T**		**P**	
3. Course Code	17070203	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

The course unit aims to introduce the basic ideas of Topological spaces. This course is designed as a basic introductory course in the analysis of metric.

9. Course Objectives:

The objectives of this course are to:

1. To introduce students to the concepts of open and closed sets not necessarily only on the real line approach.
2. To introduce the students about applications of above to proving continuous functions.
3. To introduce the students how to generate new topologies from a given set with bases.
4. To provide the awareness of tools for students to carrying out advanced research work in Pure mathematics.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the basic concept of Topology and its properties.
2. To apply the topological space to discuss the stability of various mathematical models.
3. To use the topological space for discussing the existence and uniqueness of fixed point theorems.
4. To solve mathematical problems such as differential equation, dynamic systems, knot theory and Riemann surfaces and string theory in physics.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Topological Space**

Definition and examples of topological space, Door space, Closed sets, Closure, Dense subset, Neighborhoods, interior, exterior, boundary and accumulation points, Derived sets, Bases and sub-bases, Subspaces, product spaces and relative topology.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Continuous Functions &Connectedness**

Continuous functions, homeomorphisms, the pasting lemma, properties of continuous functions, open & closed mappings, Connected and disconnected sets, connectedness on the real line, components, locally connected spaces.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Compactness**

Compactness – Continuous functions and compact sets, basic properties of compactness, compactness and finite intersection property, sequentially and countably compact sets, local compactness.

Unit – 4	**Number of lectures = 10**	**Title of the unit: Separation Axioms**

First countable space, second countable space and Separable space, Lindelof's theorems Separation axioms – T_0, T_1, T_2, T_3, $T3_{½}$, T_4, their characterizations and basic properties. Urysohn's lemma and Teitze extension theorem, Statement of Urysohn'smetrization theorem, Statements of Tychonoff's product theorem and Stone-cechcompactification theorem.

12. Brief Description of self-learning / E-learning component

https://wolfweb.unr.edu/homepage/jabuka/Classes/2009_spring/topology/Notes/02%20%20Topological%20spaces.pdf

http://www.math.muni.cz/~koren/EssentialTopology.pdf

http://home.iitk.ac.in/~chavan/topology_mth304.pdf

http://nptel.ac.in/courses/111106054/Chapter3.pdf

13. Books Recommended:

1. J. R. Munkres, Topology, A First Course, PHI Pvt. Ltd., N. Delhi, 2000.
2. Misney A. Morris, "Topology without Tears, 2011.
3. S. Willard, General Topology, Addison-Wesley, Reading, 1970.
4. W. J. Pervin, Foundations of General Topology, Academic Press Inc., New York, 1964.
5. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by PHI).
6. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.
7. K.P. Gupta, Topology, PragatiPrakashan, 2015.
8. K D Joshi, Introduction to General Topology, Wiley Eastern Ltd., 1983

1. Name of the Department: Mathematics						
2. Course Name	Functional Analysis	**L**	**T**		**P**	
3. Course Code	17070204	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

This course is for students who are majors in pure mathematics or who need functional analysis in their applied mathematics courses. Functional analysis is the branch of mathematics concerned with the study of spaces of functions. This course is intended to introduce the student to the basic concepts and theorems of functional analysis and its applications.

9. Course Objectives:

The objective of the module is to study linear mappings defined on Banach spaces and Hilbert spaces, especially linear functionals (real valued mappings) on L(p), C[0, 1] and some sequence spaces. In particular, the four big theorems in functional analysis, namely, Hahn-Banach theorem, uniform boundedness theorem and open mapping theorem will be covered

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the basic knowledge of normed linear spaces and Banach spaces.
2. To analyze the completeness (Banach space) of various spaces by using normed spaces.
3. To apply the normed space and Hilbert space for solving many real life problems such as integral equations and differential equation.
4. To discuss many research problems on the open mapping theorem, closed graph theorem, Hahn-Banach theorem.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Normed Linear Spaces**

Normed linear spaces, Metric on normed linear spaces, Completion of a normed space, Banach spaces, subspace of a Banach space, Holder and Minkowski inequality, Completeness of quotient spaces of normed linear spaces. Completeness of lp, Lp ,Rn , Cn and C[a,b]. Incomplete normed space

Unit – 2	**Number of lectures = 10**	**Title of the unit: Bounded Linear Transformations**

Finite dimensional normed linear spaces and Subspaces, Bounded linear transformation, Equivalent formulation of continuity, Spaces of bounded linear transformations, Continuous linear functional, Conjugate spaces. Hahn-Banach extension theorem (Real and Complex form).

Unit – 3	**Number of lectures = 10**	**Title of the unit: Bounded Linear Functionals**

Riesz Representation theorem for bounded linear functionals on Lp and C[a,b]. Second conjugate spaces, Reflexive space, Uniform boundedness principle and its consequences, Open mapping theorem and its application, Projections, Closed Graph theorem.

Unit – 4	Number of lectures = 10	Title of the unit: Banach Spaces
Equivalent norms, Weak and Strong convergence, Their equivalence in finite dimensional spaces. Weak sequential compactness, Solvability of linear equations in Banach spaces. Compact operator and its relation with continuous operator, Compactness of linear transformation on a finite dimensional space, Properties of compact operators, Compactness of the limit of the sequence of compact operators.		
12. Brief Description of self learning / E-learning component		
http://www.nptelvideos.com/lecture.php?id=13908 https://link.springer.com/book/10.1007/978-3-319-06728-5		
13. Books Recommended		
1. H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4 th Edition, 1993. 2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley. 3. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963. 4. A. H. Siddiqi, Khalil Ahmad and P. Manchanda, Introduction to Functional Analysis with Applications. 5. K.C. Rao, Functional Analysis, Narosa Publishing House, Second edition.		

1. Name of the Department: Mathematics						
2. Course Name	Probability and Statistics	**L**	**T**		**P**	
3. Course Code	17070205	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 40	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course introduces fundamental concepts, theories and primitive applications of probability and mathematics statistics. This course develops the building blocks of probability theory that are necessary to understand statistical inference. In this course the concept of probability and their axioms are reviewed, discrete and continuous random variables are introduced, and their properties are developed in the univariate and bivariate setting.Moment generating functions of a random variable is defined, Chebyshev's inequality, law of large numbers, central limit theorem, Basic introduction to Sampling theory, creation of test statistics, hypothesis testing and estimation, evaluation of confidence intervals.

9. Course Objectives:

1. To provide students with a good understanding of the theory of probability, both discrete and continuous, including variety of useful distributions, expectation and variance, analysis of sample statistics, and central limit theorems.
2. To help students develop the ability to solve problems using probability.
3. To introduce students to some of the basic methods of statistics and prepare them for further study in statistics.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand about data collection, organization, analysis, interpretation and presentation of data.
2. To solve statistical data using descriptive statistics and inferential statistics.
3. To use statistical inference methods like regression analysis, hypothesis testing and analysis of variance etc.
4. To solve research problems related to vast statistical data, analyzed and interpreted statistical data to identify significant differences in relationships among sources of information.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Standard Distributions**

Probability mass function, probability density function and cumulative distribution functions,distribution of a function of a random variable, Mathematical expectation, moments and moment generating function, Introduction to probability distributions: binomial, negative binomial, geometric, Poisson, hypergeometric, uniform, exponential, gamma, beta and normal distributions. Poisson and normal approximations of a binomial distribution.

Unit - 2	**Number of lectures = 10**	**Title of the unit: Functions of Random variables**

Random variable and probability functions: Definition and properties of random variables, Discrete and continuous random variables, Probability mass and density functions, Distribution function. Mathematical expectation: Definition and its properties. Variance, Covariance, Moment generating function-Definitions and their properties. Chebyshev's inequality, law of large numbers, central limit theorem.

Unit - 3	**Number of lectures = 10**	**Title of the unit: Probability distributions**

Discrete distributions: Uniform, Bernoulli, Binomial, Poisson and Geometric distributions with their properties. Continuous distributions: Uniform, Exponential, Gamma, Beta and Normal distributions with their properties.

Unit - 4	**Number of lectures = 10**	**Title of the unit: Sampling distribution and Test Statistics**

Population, sample, parameter and statistics, Simple random sampling with replacement and without replacement, sampling distribution of statistic, standard error, Fundamental sampling distribution from normal population viz. Chi-square distribution, Student's t distribution, Snedecor's F-distribution, Fisher's - Z distribution.

12. Brief Description of self learning / E-learning component

1. http://nptel.ac.in/courses/111105041/1
2. https://www.youtube.com/watch?v=r1sLCDA-kNY
3. https://www.youtube.com/watch?v=9EqUH9wsM6c

13. Books Recommended

1. R.V. Hogg and T. Craig, Introduction to Mathematical Statistics , 7th addition, Pearson Education Limited-2014
2. Zhou Sheng, ShiqianXie, Chengyi Pan, Probability and Mathematics Statistics, 4th Edition, Higher Education Press, 2011
3. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi, 2014
4. Rick Durrett, Probability: Theory and Examples, Cambridge University Press, 2010
5. Jun Shao, Mathematical Statistics, Springer-Verlag, 2010

1. Name of the Department: Mathematics						
2. Course Name	Probability and Statistics Lab	**L**	**T**		**P**	
3. Course Code	17070206	0	0		4	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 0		**Tutorials = 0**		**Practical =52**		

8. Course Description:

This course introduces fundamental concepts, theories and primitive applications of probability and mathematics statistics. This course develops the building blocks of probability theory that are necessary to understand statistical inference. In this course the concept of probability and their axioms are reviewed, discrete and continuous random variables are introduced, and their properties are developed in the univariate and bivariate setting.In particular, we discuss the most common probability distributions that arise in statistical applications.

Topic includes: Concept of Probability, Bayes theorem and its applications, Random variables, Mathematical expectation, Moment generating function, Chebyshev's inequality, law of large numbers, central limit theorem and some common probability distributions that arise in statistical applications etc.

9. Course Objectives:

1. To provide students with a good understanding of the theory of probability, both discrete and continuous, including variety of useful distributions, expectation and variance, analysis of sample statistics, and central limit theorems.
2. To help students develop the ability to solve problems using probability.
3. To introduce students to some of the basic methods of statistics and prepare them for further study in statistics.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To investigate mathematical mistakes and produce accurate figures in their research if they input all data correctly.
2. To use statistical software for statistical computing, data optimization and graphical representation.
3. To solve different data related problems for getting significant results of complex problems.
4. To introduce more advanced data analysis methods: the multiple regression model, and descriptive analysis of temporal and multivariate data.

11. Mathematical Statistics Lab Syllabus:

Practical Based on Syllabus: Programming in "C" or Applying software packages for problems based on Theory paper Probability & Mathematical Statistics (08030105).

Use of Statistical Software packages such as MINITAB, SPSS, Statgraf etc.

Practical Exercises for Statistical techniques based on topics in paper Probability & Mathematical

Statistics (08030105).

Note:

1. At least eight experiments are to be performed in the semester.
2. At least three experiments are based on Software and remaining experiments are based on conventional methods.
3. At least six experiments should be performed from the above list. Remaining two experiments may either be performed from the above list or designed & set by the department as per the scope of the syllabus.

12. Brief Description of self learning / E-learning component

1. http://nptel.ac.in/courses/111105041/1
2. https://www.youtube.com/watch?v=r1sLCDA-kNY
3. https://www.youtube.com/watch?v=9EqUH9wsM6c

13. Books Recommended

1. R.V. Hogg and T. Craig, Introduction to Mathematical Statistics , 7th addition, Pearson Education Limited-2014
2. Zhou Sheng, ShiqianXie, Chengyi Pan, Probability and Mathematics Statistics, 4th Edition, Higher Education Press, 2011
3. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi, 2014
4. Rick Durrett, Probability: Theory and Examples, Cambridge University Press, 2010
5. Jun Shao, Mathematical Statistics, Springer-Verlag, 2010

1. Name of the Department: Mathematics							
2. Course Name	Research Methodology and Technical Writing	**L**	**T**		**P**		
3. Course Code	17070207	3	0		0		
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem()	
7. Total Number of Lectures, Tutorials, Practical							
Lectures = 40		**Tutorials = 0**		**Practical = 0**			

8. Course Description:

This course will provide an opportunity for students to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. The students will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in forming their understanding of their work, social, local and global environment.

9. Course Objectives:

To enable researchers (Ph.D., M. Tech. students), irrespective of their discipline, in developing the most appropriate methodology for their research studies. To make them familiar with the art of using different research methods and techniques.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the literature of research, process of the research and identification of appropriate research topic.
2. To understand the authentication of the statistical data and interpretation of results of research topics.
3. To understand the skills and ethics of research articles for the suitable publications.
4. To formulate of the research problem, analyses and simulation.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Fundamental Research**

Research, types of research, Research vs research methods, Research process, Relevant and quality research. Problem-solving in engineering, Identification of research topic, Problem definition, Literature survey, literature survey, Literature review, Research Design.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Formulation and simulation**

Models in general, Mathematical models, Model classifications, Modeling of engineering systems Theoretical models, Empirical models, Model evaluation, Limitations of mathematical models. Simulation models, Steps in a simulation study, Simulation software, Validation and data collection, Applications.

Unit – 3	**Number of lectures = 10**	**Title of the unit: ANALYSIS AND INTERPRETATION OF DATA**

Formulation of Hypothesis, Testing of hypothesis, Analysis of variance, Design of experiments,

Multivariate analysis, Simple regression and correlation, measurement & scaling techniques, Data checking, Data analysis, Statistical, Graphical and Numerical data analysis, Interpretation of results in research , need for Interpretation, Accuracy, Precision, Uncertainty and variability, Repeatability and reproducibility, Error definition and classification, Analysis of errors, Statistical analysis of errors.

Unit – 4	**Number of lectures = 10**	**Title of the unit: SKILLS AND ETHICS IN RESEARCH**
Basic communication model, Preparing papers for journals, synopsis of research work, Reference citation, Listing of References. Thesis writing, Steps in writing the report, presentation of graphs, figures, tables, Structure of thesis report, main body of thesis, summary, references, Evaluation of a thesis, Ethics in research, Intellectual property rights, copyright laws, Patent rights.		

12. Brief Description of self learning / E-learning component

13. Books Recommended

1. Research Methodology for Engineers- R Ganeshan, MJP Publishers. 2011.
2. Research Methodology- C R Kothari, New Age International, 2004.
3. Research Methodology: A step by step guide for beginners- Ranjit Kumar, Sage Publications, 2010.
4. Research Methods- R. Panneerselvan, Prentice Hall, 2004.

1. Name of the Department: Mathematics							
2. Course Name	Programming with Python	**L**	**T**		**P**		
3. Course Code	17070208	3	0		0		
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()	
7. Total Number of Lectures, Tutorials, Practical							
Lectures = 40		**Tutorials =0**		**Practical = 0**			

8. Course Description:

The goal of this course is to provide an introduction to Python. The course will discuss topicsnecessary for the participant to be able to create and execute Python programs. The lectures and presentations are designed to provide knowledge and experiences to students that serve as a foundation for continued learning of presented areas.

9. Course Objectives:

- Master the fundamentals of writing Python scripts
- Learn core Python scripting elements such as variables and flow control structures
- Discover how to work with lists and sequence data
- Write Python functions to facilitate code reuse
- Use Python to read and write files
- Make their code robust by handling errors and exceptions properly
- Work with the Python standard library
- Explore Python's object-oriented features
- Search text using regular expressions

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To install and run the Python interpreter.
2. To understand the concepts of file I/O and create and execute Python programs.
3. To enable to read data from a text file using Python.
4. To plot data using appropriate Python visualization libraries.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Introduction**

The Python Programming Language, History, features, Installing Python, Running Python program, Debugging, Syntax Errors, Runtime Errors, Semantic Errors, Experimental Debugging, Formal and Natural Languages, The Difference Between Brackets, Braces, and Parentheses.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Variables and Expressions**

Values and Types, Variables, Variable Names and Keywords, Type conversion, Operators and Operands, Expressions, Interactive Mode and Script Mode, Order of Operations, Conditional Statements: if, if-else, nested if –else, Looping: for, while, nested loops, Control statements: Terminating loops, skipping specific conditions.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Functions and Mathematical expression**

Function Calls, Type Conversion Functions, Math Functions, Composition, Adding New Functions, Definitions and Uses, Flow of Execution, Parameters and Arguments, Variables and Parameters Are Local, Stack Diagrams, Fruitful Functions and Void Functions, Why Functions? Importing with from, Return Values, Incremental Development, Composition, Boolean Functions, More Recursion, Leap of Faith, Checking Types		
Unit – 4	**Number of lectures = 10**	**Title of the unit: Python Strings**
Quotation Marks and SpecialCharacters, StringIndexing, SlicingStrings, Concatentaion andRepetition, Common, StringMethods, StringFormatting, Formatted String Literals(f-strings, Built-in StringFunctions		
12. Brief Description of self learning / E-learning component		
13. Books Recommended		
1. Jason Montojo, Jennifer Campbell, Paul Gries, An Introduction to Computer Science using Python 3, SPD, 2014. 2. P. K. Sinha & Priti Sinha , "Computer Fundamentals", BPB Publications, 2007. 3. T. Budd, Exploring Python, TMH, 1st Ed, 2011		

1. Name of the Department: Mathematics						
2. Course Name	Discrete Mathematics	**L**	**T**		**P**	
3. Course Code	17070301	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

Introduction to discrete structures and their applications like logic, gate and set theory, recursive programming, digital logic and combinatorial circuits, real number representation and finite automata used in computer science.

9. Course Objectives:

To provide basic and theoretical competencies that is majorly used in Computer Science. To help students understand and appreciate the basic mathematical knowledge which is fundamental to Computer Science.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To discuss the validity of arguments using logical operators, Boolean algebra as lattices and Graph theory.
2. To apply Boolean algebra in switching theory such as AND, OR and NOT gates.
3. To analyze several mathematical and computational problems through graph theory.
4. To design and construction of a combinatorial circuit from a verbal description.

11. Unit wise detailed content

Unit-1	**Number of lectures = 12**	**Title of the unit: Logics, Algebraic Structure and Lattices**

Formal Logic: Statement, Symbolic representation, tautologies, quantifiers, predicates and validity, propositional logic. Semi groups and Monoids: Definitions and examples of semi groups and monoids (including those pertaining to concentration operations). Homomorphism of semi groups and monoids, Congruence relation and quotient semi groups, sub semi groups and sub monoids, Direct products basic homomorphism theorem. Lattices: Lattices as partially ordered sets, their properties. Lattices and algebraic systems.

Unit – 2	**Number of lectures = 8**	**Title of the unit: Boolean Algebra**

Boolean Algebra as Lattices, Various Boolean Identities Join-irreducible elements. Atoms and Minterms. Boolean Forms and their Equivalence. Minterm Boolean Forms, Sum of Products Canonical Forms. Minimization of Boolean Functions. Applications of Boolean Algebra to Switching Theory (using AND, OR and NOT gates). The Karnaugh Map method.

Unit – 3	**Number of lectures = 12**	**Title of the unit: Graph Theory.**

Definition of (undirected) Graphs, Paths, Circuits, Cycles and Subgroups. Induced Subgraphs. Degree of a vertex. Connectivity, Planar Graphs and their properties. Trees, Spanning Trees. Minimal Spanning Trees and Kruskal'sAlgorithum, Matrix Representations of Graphs. Euler's Theorem on the Existence of Eulerian Paths and Circuits. Directed Graphs. Indegree and Outdegree of a Vertex. Weighted undirected

Graphs.		
Unit – 4	**Number of lectures = 08**	**Title of the unit: Theory of Automata**
Introductory Computability Theory – Finite state machines and their transition table diagrams. Equivalence of finite state machines. Reduced Machines, Homomorphism. Finite automata. Acceptors. Moore and Mealy Machines.		
12. Brief Description of self learning / E-learning component		
www.youtube.com/watch?v=7k4Di5u-oUU&index=12&list=PL0862D1A947252D20 www.youtube.com/watch?v=_BIKq9Xo_5A&index=13&list=PL0862D1A947252D20 www.youtube.com/watch?v=RMLR2JHHeWo&list=PL0862D1A947252D20&index=14 www.youtube.com/watch?v=fZqfkJ-cb28&list=PL0862D1A947252D20&index=17 www.youtube.com/watch?v=Fk8nJjzohr8&index=22&list=PL0862D1A947252D20		
13. Books Recommended		
1. Discrete Mathematics , M.K. Venkataraman, The National Publishing Company 2. Discrete Mathematical Structures with Applications to Computer Science J.P. Trembly and Manohar, Tata McGraw-Hill Publications. 3. Elements of Discrete Mathematics, Liu, Tata Mac Graw Hills. 4. Kolman B, Busby R.C. and Ross S., Discrete Mathematical Structures for Computer Science, Fifth Edition, Prentice Hall of India, New Delhi, 2006. 5. Baburam, Discrete Mathematics , Pearson Education 2010		

1. Name of the Department: Mathematics						
2. Course Name	Mathematical Modelling and Simulation	**L**	**T**		**P**	
3. Course Code	17070302	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**	**Practical = 0**			
8. Course Description:						
Formulation and analysis of mathematical models. Mathematical tool include dimensional analysis, optimization, simulation, probability, and elementary differential equations. Applications to biology, sports, economics, and other areas of science. The necessary mathematical and scientific background will be developed as needed. Students will participate in formulating models as well as in analyzing them.						
9. Course Objectives:						
The objective of the course is to introduce the concept of representation of real world situations into Mathematical situations.						
10. Course Outcomes (COs):						
By the end of this course, students should be able: 1. To understand the core principles of mathematical modeling. 2. To apply precise and logical reasoning to problem solving. 3. To frame quantitative problems and model through difference equations them mathematically. 4. To analyze the importance of graph theory in mathematical modeling						
11. Unit wise detailed content						
Unit-1	**Number of lectures = 12**	**Title of the unit: Introduction**				
The technique on Mathematical Modelling, Mathematical Modelling through Calculus, Mathematical Modelling through ordinary differential equation of first order, Linear Growth and Decay model, Nonlinear Growth and Decay model, Mathematical Modelling in dynamics through ordinary differential equation of first order.						
Unit – 2	**Number of lectures = 12**	**Title of the unit: Mathematical Modelling through System of Differential Equations**				
Mathematical Modelling in population dynamics, Mathematical Modelling of Epidemics through system of differential equation of first order, Mathematical Modelling in Economics based on system of differential equation of first order, Mathematical Modelling in Medicine, Arms, Race Battles and International Trade in terms of ordinary differential equations.						
Unit – 3	**Number of lectures = 8**	**Title of the unit: Mathematical Modelling through Difference Equations**				
Need of Mathematical Modelling through Difference Equations, Mathematical Modelling through Difference Equations in Economics, Finance, Population dynamics and genetics.						
Unit – 4	**Number of lectures = 8**	**Title of the unit: Mathematical Modelling through Graphs**				
Environment that can be modelled through Graphs, Mathematical Modelling in terms of Directed Graphs,						

Signed Graphs, weighted Diagraphs, Non-oriented Graphs.
12. Brief Description of self learning / E-learning component
1. **http://mathforum.org** 2. **http://ocw.mit.edu/ocwweb/Mathematics**
13. Books Recommended
1. Kapur, J. N. (1988). Mathematical Modelling. New Age International. 2. Barnes, B., Fulford, G. R. (2008). Mathematical Modelling with Case Studies, CRC Press. 3. Bender, E. A. (2012). An introduction to mathematical modeling. Courier Corporation. 4. Meerschaert, M. M. (2013). Mathematical Modelling, Academic Press.

1. Name of the Department: Mathematics						
2. Course Name	Differential Geometry	**L**	**T**		**P**	
3. Course Code	17070303	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 40	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course comprise application of calculus and algebra to the geometry of curves surfaces in spaces. This course consists of tensor, Riemann Chrisoffel and metric spaces, tangent space, different types of curvature and involutes, Manifold, submanifold and geometry of manifold.

9. Course Objectives:

The primary objective of this course is to provide basic knowledge of manifolds, submanifolds and geometry of manifolds.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand about differentiation of functions of several variables, tangent vector, vector field, differential forms and Connections.
2. To analyze the topological manifold using homeomorphism.
3. To apply tangent vectors and tangent space for discussing the differentiable structure on a manifold.
4. To solve many research problems on torsion, curvature, tensor and Lie algebra.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Basic Calculus of $\mathbb{R}^n$**

Differentiable functions from $\mathbb{R}^n \to \mathbb{R}^m$, Chain rule, Directional derivatives, Differential of a map, Chain rule for differentials, Inverse mapping theorem, Implicit function theorem.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Manifold and its differentiable structure**

Topological manifolds, Differentiable atlas, Smooth maps, Diffeomorphism, Equivalent atlases, Differentiable structure on a manifold, Space of smooth maps, Tangent vectors and tangent space, Differential of a smooth map.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Submanifolds, Vector fields and Covectors**

Immersion, Embedding and Submanifolds, Vector fields, Lie algebra of vector fields, Integral curve of a vector field, Covectors and Cotangent spaces, Pull back of a linear differential form, One parameter group of transformation, Exponential map, Covariant and Contravariant tensors, Laws of transformation for the components of tensors.

Unit – 4	**Number of lectures = 10**	**Title of the unit: Differential forms and Connection**

Differential forms, Exterior product, Grassman algebra of forms, Exterior derivative, Affine Connection, Parallelism, Geodesic Covariant differentiation of tensors, Torsion and Curvature of a Connection, Structure equation of Cartan, Bianchi's identities.

12. Brief Description of self-learning / E-learning component
https://www.youtube.com/watch?v=tKnBj7B2PSg&list=PLLq_gUfXAnkl5JArcktbOrIUeR5rra-Gz https://www.youtube.com/watch?v=6xgtMQ7WSzQ https://www.youtube.com/watch?v=_mvjOoTieTk&list=PLIljB45xT85DWUiFYYGqJVtfnkUFWkKtP
13. Books Recommended
1. W. M. Boothby: An Introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, Revised Ed, 2003. 2. S. I. Husain: Lecture Notes on Differentiable Manifolds. 3. K. Matsushima: Differentiable Manifolds. 4. S. Kumaresan: A Course in Differential Geometry and Lie groups

1. Name of the Department: Mathematics							
2. Course Name	Special Functions	**L**	**T**		**P**		
3. Course Code	17070304	3	0		0		
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem()	

7. Total Number of Lectures, Tutorials, Practical

Lectures = 40	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course covers some fundamental topics of special functions like as Laguerre, Hermite and Jacobi polynomials. In this course the students will be taught Gamma and Beta functions, Hypergeometric functions and their properties and orthogonality of Laguerre, Hermite and Jacobi polynomials.

9. Course Objectives:

1. The interplay between Euler's integral of Gamma function and properties of gamma and Beta functions
2. To investigate and derive the properties of hyper geometric and Confluent hypergeometric functions and their representations in various forms.
3. To study about the properties of special functions as well as orthogonal polynomials.
4. To know the certain specific systems of orthogonal polynomials and their properties.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the basic concepts of Gamma and Beta functions and their properties.
2. To analyze the generating functions, recurrence relation and Rodrigue's formulas of the various orthogonal polynomials.
3. To determine the various integrals in terms of Hypergeometric and Confluent hyper geometric functions.
4. To solve many research problems of computational fluid dynamics using special functions.

11. Unit wise detailed content

Unit-1	**Number of lectures = 12**	**Title of the unit: The Gamma and Beta Functions**

Eulers' integral for$\Gamma(z)$, the beta function, factorial function,Legendre's duplication formula, Gauss's multiplication theorem, summation formula due to Euler, behaviour of log $\Gamma(z)$ for large $|z|$, relation between functions of $\Gamma(z)$ and, $\Gamma(1-z)$.

Unit – 2	**Number of lectures = 08**	**Title of the unit: Hypergeometric and Confluent Hypergeometric Functions**

An integral representation. Its differential equation and solution,F(a,b,c;1) as a function of the parameters, evaluation of F(a,b,c;1), contiguous function relations, the hypergeometric differential equation, logarithmic solutions of the hypergeometric equation, F(a,b,c;z) as a function of its parameters, Elementary series manipulations, simple transformations, quadratic transformations, theorem due to Kummer, additional properties, Basic properties of1F1, Kummer's first formula, Kummer's second formula. Ramanujan's product theorems.

Unit – 3	**Number of lectures = 08**	**Title of the unit: Laguerre, Hermite and Jacobi Polynomials**

Series solution of Differential equations, Generating functions , recurrence relations, Rodrigues' formula,

Integral representation, Expansion of x^n in terms of Hermite polynomials, Laguerre polynomials, Jacobi polynomials		
Unit – 4	**Number of lectures = 12**	**Title of the unit: Orthogonal Polynomials**
Simple sets of polynomials; Orthogonal polynomials: Equivalent condition for orthogonality; Zeros of orthogonal polynomials; Expansion of polynomials; Three-term recurrence relation; Christoffel- Darboux formula; Normalization and Bessel's inequality; Orthogonality of Legendre, Hermite and Laguerre polynomials; Ordinary and singular points of differential equations, Regular and irregular singular points of hypergeometric, Bessel, Legendre, Hermite and Laguerre differential equations; Examples on above topics.		
12. Brief Description of self learning / E-learning component		
13. Books Recommended		
1. E. D. Rainville: Special Functions, Chelsea Publishing Co., Bronx, New York, Reprint,1971. 2. W. Jr. Miller: Lie Theory and Special Functions, Academic Press, New York and London,1968. 3. E. B. McBride: Obtaining Generating Functions, Springer Verlag, Berlin Heidelberg,1971. 4. T.S, Chihara, An Introduction to Orthogonal Polynomials, Dover, Publications, 2011.		

1. Name of the Department: Mathematics						
2. Course Name	Fuzzy Sets & its Applications	**L**	**T**		**P**	
3. Course Code	17070305	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. re-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 40	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course provides the fundamentals of classical set theory and fuzzy set theory. The decomposition theorems of fuzzy sets and the extension principle will be introduced, as well as the use of nonlinear integrals as aggregation tools to deal with fuzzy data. As an indispensable tool in fuzzy decision making, ranking and ordering fuzzy quantities will be discussed.

9. Course Objectives:

This course introduces students to the basic concepts of modeling in systems using fuzzy sets. The concepts of fuzzy sets are introduced and their role in applications of semantic interpreters, control systems and reasoning systems.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To recognize uncertainty, vagueness, imprecision and phenomena which traditional methodologies (like, crisp set etc.) cannot study adequately.
2. To introduce fuzzy measures and measure of fuzziness.
3. To apply fuzzy set theory and fuzzy logic approaches in complex technological problems.
4. To describe research problem related to knowledge-based systems, linguistic data problem using fuzzification and defuzzification methods.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Basic Fuzzy Sets**

Basic definitions, α -level sets, comparison with classical (crisp) sets,Types of fuzzy sets, extension principle, Fuzzy complement, t-norms, t-co-norms, combination of operations, aggregation operations. Fuzzy numbers, linguistic variables, arithmetic operations on intervals, arithmetic operations on fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Crisp versus fuzzy relation**

Crisp versus fuzzy relation, projections and cylindrical extensions, binary fuzzy relations, binary relations on a single set, fuzzy equivalence relations, fuzzy compatibility and fuzzy ordering relations.Fuzzy measures, evidence theory, possibility theory, fuzzy sets and possibility theory.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Fuzzy Logic**

An overview of classical logic, multi valued logic, fuzzy propositions, fuzzy quantifiers, and linguistic hedges, Inference from conditional fuzzy propositions, Inference from conditional and qualified propositions. Information and uncertainty, non-specificity of crisp and fuzzy sets, fuzziness of fuzzy sets

Unit – 4	**Number of lectures = 10**	**Title of the unit: Fuzzy Linear Programming**

Individual, multiperson, multicriteria decision making, fuzzy ranking method, fuzzy linear programming.

Methods of de-fuzzyfication.
12. Brief Description of self-learning / E-learning component
https://cours.etsmtl.ca/sys843/REFS/Books/ZimmermannFuzzySetTheory2001.pdf https://www.worldscientific.com/worldscibooks/10.1142/2867#t=toc https://www.tutorialspoint.com/fuzzy_logic/fuzzy_logic_set_theory.htm
13. Books Recommended
1. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi. 2. H.J. Zimmermann, Fuzzy Set Theory & its Applications, Allied Publishers Ltd. New Delhi. 3. Timothy J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hills inc. New Delhi

1. Name of the Department: Mathematics						
2. Course Name	Fluid Dynamics	**L**	**T**		**P**	
3. Course Code	17070306	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC(✓)**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials =0**		**Practical = 0**		

8. Course Description:

This course covers the mathematical description of fluid flow in terms of Lagrangian and Eulerian coordinates; the derivation of the Navier-Stokes equations from the fundamental physical principles of mass and momentum conservation; use of the stream function, velocity potential and complex potential are introduced to find solutions of the governing equations for inviscid, irrotational flow past bodies and the forces acting on those bodies; analytic and numerical solutions of the Navier-Stokes equation.

9. Course Objectives:

Prepare a foundation to understand the motion of fluid and develop concept, models and techniques which enables to solve the problems of fluid flow and help in advanced studies and research in the broad area of fluid motion.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the concept of fluid and their classification, models and approaches to study the fluid flow.
2. To formulate mass and momentum conservation principle and obtain solution for nonviscous flow.
3. To understand the concept of stress and strain in viscous flow and to derive Navier–Stokes equation of motion and solve some exactly solvable problems.
4. To analyze some three dimensional motions problems, Weiss's and Butler's sphere theorems and Kelvin's inversion theorem.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Motion of fluid**

Classification of fluids, Continuum model, Eulerian and Lagrangian approach of description, Differentiation following the fluid motion, Irrotational flow, Vorticity vector, Equipotential surfaces, Streamlines, pathlines and streak lines of particles, Stream tube and stream surface, Mass flux density, Conservation of mass leading to equation of continuity (Euler's form), Boundary surface, Conservation of momentum and its mathematical formulation (Euler's form), Integration of Euler's equation under different conditions, Bernoulli's equation, steady motion under conservative body forces.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Incompressible fluid**

Theory of irrotational motion, Kelvin's minimum energy and circulation theorems, Potential theorems, Two-dimensional flows of irrotational, incompressible fluids, Complex potential, Sources, sinks, doublets and vortices, Milne–Thomson circle theorem, Images with respect to a plane and circles, Blasius theorem.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Three dimensional flow**

Three-dimensional flows, Sources, sinks, doublets, Axi-symmetric flow and Stokes stream function,

Butler sphere theorem, Kelvin's inversion theorem, Weiss's sphere theorem, Images with respect to a plane and sphere, Axi-symmetric flows and stream function, Motion of cylinders and spheres.		
Unit – 4	**Number of lectures = 10**	**Title of the unit: Viscous fluid**
Viscous flow, stress and strain analysis, Stokes hypothesis, Navier–Stokes equations of motion, Some exactly solvable problems in viscous flows, Steady flow between parallel plates, Poiseuille flow, Steady flow between concentric rotating cylinders.		
12. Brief Description of self learning / E-learning component		
13. Books Recommended		
1. F. Chorlton, Text Book of Fluid Dynamics, CBS Publisher, 2005. 2. R.W. Fox, P.J. Pritchard and A.T. McDonald, Introduction to Fluid Mechanics, Seventh Edition, John Wiley & Sons, 2009. 3. P.K. Kundu, I.M. Cohen, D.R. Dowling, Fluid Mechanics, Sixth Edition, Academic Press, 2016.		

1. Name of the Department: Mathematics						
2. Course Name	Numerical Analysis and its Applications	**L**	**T**		**P**	
3. Course Code	17070307	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 40	**Tutorials = 0**	**Practical = 0**

8. Course Description:

Numerical Analysis and its Applications cover the following points:

1. Basics of Numerical Analysis
2. System of Linear Algebraic Equations and Eigen Value Problems
3. Numerical Solution Of Ordinary Differential Equations
4. Numerical Solution Of Partial Differential Equations

9. Course Objectives:

Numerical Methods is a powerful problem solving tools in it student is capable to solve different problems analytically like Linear Equations, ODE, PDE, Differentiations and Integrations, Interpolation.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To study of algorithms that use numerical approximation (as opposed to symbolic manipulations) for the problems of mathematical analysis.
2. To use numerical analysis for describes a root finding method for solving a simple equation and calculation of different measures.
3. To perform different numerical techniques viz. Interpolation, extrapolation, direct methods and Iterative methods.
4. To evaluate Computer aided design (CAD) and computer aided manufacturing (CAM) numerical methods are important research areas within engineering.

11. Unit wise detailed content

Unit – 1	**Number of lectures = 8**	**Title of the unit: Basics of Numerical Analysis**

Finite difference operators, Basics of Numerical Differentiation and Integration, Relaxation method and its convergence, Muller's method for complex and multiple roots, Cubic Spline, Romberg's Integration, Richardson's Extrapolation.

Unit-2	**Number of lectures = 8**	**Title of the unit: System of Linear Algebraic**

		Equations and Eigen Value Problems
Direct Methods, Error Analysis for Direct Methods, Eigen Values and Eigen vectors, Bounds on Eigen Values, Jacobi, Givens and Housholder's Methods for Symmetric Matrices, Rutishauser Method for Arbitrary Matrices, Power and Inverse Power methods, Choice of a Method.		
Unit – 3	**Number of lectures = 12**	**Title of the unit: Numerical Solution Of Ordinary Differential Equations**
Introduction. RungeKutta methods derivation, error bounds and error estimates. Weak stability theory for RungeKutta methods. Order and convergence of the general explicit one step methods. Linear multi step methods derivation, order consistency, zero stability and convergence. Weak stability theory for general linear multi step methods. Predictor Corrector methods, Stiff systems.		
Unit – 4	**Number of lectures = 12**	**Title of the unit:Numerical Solution Of Partial Differential Equations**
Basic linear algebra vector and matrix norms and related theorems. Parabolic equations in one and two space dimensions explicit and implicit formulae. Consistency, stability and convergence. Iterative methods for linear systems. Split operator methods. Multilevel difference schemes. Nonlinear equations. Elliptic Equations Dirichlet, Neumann and mixed problems. Direct factorization methods and successive over relaxation (S.O.R.). ADI and conjugate gradient methods. Hyperbolic equations. First order hyperbolic systems in one and two space dimensions stability and convergence. Second order equations in one and two space dimensions. The Galerkin method and applications.		

12. Brief Description of self learning / E-learning component

www.youtube.com/watch?v=QQFIWwDA9NM&index=4&list=PLbMVogVj5nJRILpJJO7KrZa8Ttj4_ZAgl

www.youtube.com/watch?v=rj2Mb7JGyHk&index=23&list=PLbMVogVj5nJRILpJJO7KrZa8Ttj4_ZAgl

www.youtube.com/watch?v=rMC6yvc7a6s&list=PLbMVogVj5nJRILpJJO7KrZa8Ttj4_ZAgl&index=27

www.youtube.com/watch?v=9YWjoiE4Wck&list=PLbMVogVj5nJRILpJJO7KrZa8Ttj4_ZAgl&index=33

13. Books Recommended:

1. B.S. Grewal, "Numerical Methods in Engineering & Science", Khanna Publication, Ed. 9th.
2. E. Balagurusamy , "Numerical Method", Tata McGraw Hill Publication.
3. S.S. Sastry, "Introductory Methods of Numerical Analysis", PHI learning Pvt. Ltd.
4. Curtis F. Gerald and Patrick O. Wheatley, "Applied Numerical Analysis", Pearson Education.
5. M.K Jain, S. R. K. Iyengar and R.K Jain, "Numerical Methods for Scientific and Engineering computation", New age International Publishers.
6. V. Sundarapandian, "Numerical Linear Algebra", PHI Learning Private Limited, Delhi.

1. Name of the Department: Mathematics						
2. Course Name	Numerical Analysis and its Applications Lab	**L**	**T**		**P**	
3. Course Code	17070308	0	0		4	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures =		**Tutorials = 0**	**Practical = 52**			

8. Course Description:

This course analyzed the basic techniques for the efficient numerical solution of problems in science. Topics s covered are: matrix operations, linear equation, Solution of Linear equations for Underdetermined and Overdetermined cases, Eigen values and Eigen vectors of a Square matrix, Solution of Difference Equations, Solution of Difference Equations using Euler and Modified Euler Method, Solution of differential equation using 4th order Runge- Kutta method, Roots of a polynomial, Polynomial using method of Least Square Curve Fitting, Polynomial using method of Least Square Curve Fitting, Polynomial fit, analyzing residuals, exponential fit and error bounds from the given data, Solution of Non-linear equation in single variable using the method of successive bisection

9. Course Objectives:

Many applications in engineering, physics, geology and other specifications containing complicated problems that will require one of the numerical methods to be solved. In this course students will learn the classification of many complicated problems and the suitable numerical methods for obtaining an approximated solution to these problems with desired accuracy.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To demonstrate fundamental knowledge of numerical analysis.
2. To solve engineering problems governed by differential equations by numerical methods.
3. To implement different tools for solving various numerical analysis problems.
4. To use numerical analysis tools for solving different numerical method's problem viz. Numerical linear algebra, Interpolation and approximation and finding roots of nonlinear equations etc.

11. The list of practical's to perform in the computer lab

1. Study of basic matrix operations
2. To solve linear equation
3. Solution of Linear equations for Underdetermined and Overdetermined cases.

4. Determination of Eigen values and Eigen vectors of a Square matrix.
5. Solution of Difference Equations.
6. Solution of Difference Equations using Euler Method.
7. Solution of differential equation using 4th order Runge- Kutta method.
8. Determination of roots of a polynomial.
9. Determination of polynomial using method of Least Square Curve Fitting.
10. Determination of polynomial fit, analyzing residuals, exponential fit and error bounds from the given data.
11. Solution of Non-linear equation in single variable using the method of successive bisection.

12. Brief Description of self learning / E-learning component

http://gnindia.dronacharya.info/CSEIT/Downloads/Labmanuals/Lab_Manual_Numerical_Technique.pdf

http://www.ycetnnl.edu.in/downloads/files/n532957dd8a753.pdf

https://www.youtube.com/watch?v=FoukIaj5pP8

13. Books Recommended:

1. B.S. Grewal, "Numerical Methods in Engineering & Science", Khanna Publication, Ed. 9th.
2. E. Balagurusamy , "Numerical Method", Tata McGraw Hill Publication.
3. S.S. Sastry, "Introductory Methods of Numerical Analysis", PHI learning Pvt. Ltd.
4. Curtis F. Gerald and Patrick O. Wheatley, "Applied Numerical Analysis", Pearson Education.
5. M.K Jain, S. R. K. Iyengar and R.K Jain, "Numerical Methods for Scientific and Engineering computation", New age International Publishers.
6. V. Sundarapandian, "Numerical Linear Algebra", PHI Learning Private Limited, Delhi.

1. Name of the Department: Mathematics						
2. Course Name	Cryptography	**L**	**T**		**P**	
3. Course Code	17070309	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**		**Practical = 0**		

8. Course Description:

The art of protecting information by transforming it (encrypting it) into an unreadable format, called cipher text. Only those who possess a secret key can decipher (or decrypt) the message into plain text. Cryptography is used to protect e-mail messages, credit card information, and corporate data.

9. Course Objectives:

The objectives of this course are to:

1. To understand the fundamentals of Cryptography
2. To acquire knowledge on standard algorithms used to provide confidentiality, integrity and authenticity.
3. To understand the various key distribution and management schemes.
4. To understand how to deploy encryption techniques to secure data in transit across data networks
5. To design security applications in the field of Information technology

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the basic knowledge of number theory and algebraic numbers.
2. To prepare abstract and critical thinking background for computer science students.
3. To analyze a problem, and identify and define the computing requirements for data security
4. To develop a framework to understand and implement cryptographic aspects.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of Unit-I: Introduction to number theory**

Divisibility, Euclidean algorithm, linear Diophantine equations, prime numbers, fundamental theorem of arithmetic, discussion on the prime number theorem, Introduction to congruences, solutions of linear congruences, Chinese Remainder Theorem, Euler's totient function, Euler-Fermat theorem, Wilson's theorem, non-linear congruences, Hensel's lemma, primitive roots and power residues

Unit – 2	**Number of lectures = 12**	**Title of Unit-II: Special functions of number theory& Algebraic numbers**

Quadratic residues, quadratic reciprocity, the Jacobi symbols, The greatest integer function, arithmetic functions, Mobius function and Mobius inversion formula, Introduction to algebraic numbers, algebraic number fields, algebraic integers, quadratic fields, units in quadratic fields, primes in quadratic fields, unique factorization, primes in quadratic fields having the uniquefactorization property.

Unit – 3	**Number of lectures = 12**	**Title of Unit-III: Introduction and Public Key Encryption**

Classical Encryption Techniques: Symmetric Cipher Model, Substitution Techniques, Transposition Techniques, Stream Cipher and Block Cipher, Random Number Generator, One-time Pad.Block Cipher Principles, Data Encryption Standard (DES), Multiple Encryption, Triple DES, Advanced Encryption Standard (AES), Principles of Public Key Cryptosystems, The RSA Algorithm, Key Management, Elliptic Curve Arithmetic, Elliptic Curve Cryptography.

Unit – 4	**Number of lectures = 06**	**Title of Unit-IV: Cryptographic Protocols**

Authentication Requirement, Authentication Function, MAC, Hash Functions, Security of Hash Function , Digital Signatures

12. Brief Description of self-learning / E-learning component

https://www.youtube.com/watch?v=eFiEKu8gl_w

https://www.youtube.com/watch?v=1plMO7ChXMU

13. Books Recommended

1. Bruce Schneier, Applied Cryptography: Protocols, Algorithms, and Source Code in C, Second E/d,John Wiley & Sons, 1996.
2. William Stallings, Cryptography and Network Security: Principles and Practice, Second Edition,Prentice Hall, 1998.
3. Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag.
4. A. J. Menezes, P. C. van Oorshot and S. A. Vanstone: Handbook of Applied Cryptography, CRCPress.
5. Johannes A. Buchmann, Introduction to Cryptography, Springer 2000.
6. Douglas Robert Stinson, Cryptography - Theory and Practice, Chapman Hall / CRC 2006.

1. Name of the Department: Mathematics						
2. Course Name	Cryptography Lab	**L**	**T**		**P**	
3. Course Code	17070310	0	0		4	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 0		**Tutorials = 0**		**Practical = 52**		

8. Course Description:

This course give practical exposure on basic security attacks, encryption algorithms, authentication techniques. Apart from security algorithms, firewall configuration is also introduced.

9. Course Objectives:

1. To provide deeper understanding into cryptography, its application to network security, threats/vulnerabilities to networks and countermeasures.
2. To explain various approaches to Encryption techniques, strengths of Traffic Confidentiality, Message Authentication Codes.
3. To familiarize symmetric and asymmetric cryptography

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To understand the fundamental principles of access control models and techniques, authentication and secure system design.
2. To know a strong understanding of different cryptographic protocols and techniques and be able to use them.
3. To apply methods for authentication, access control, intrusion detection and prevention.
4. To indentify and mitigate software security vulnerabilities in existing systems.

11. At least 10 experiments from the following:

1. To implement Ceaser Cipher
2. To implement Affine Cipher with equation c=3x+12
3. To implement Playfair Cipher with key ldrp
4. To implement polyalphabetic Cipher
5. To implement AutoKey Cipher
6. To implement Hill Cipher. (Use any matrix but find the inverse yourself)
7. To implement Rail fence technique
8. To implement Simple Columner Transposition technique
9. To implement Advanced Columner Transposition technique
10. To implement Euclidean Algorithm
11. To implement Advanced Euclidean Algorithm
12. To implement Simple RSA Algorithm with small numbers
13. To implement of Hash Functions

12. E-learning resources

13. Books Recommended

1. William Stallings, Cryptography and Network security, 4e, Prentice Hall of India, New Jersey, 2008.
2. Christof Paar, Jan Pelzl, Understanding Cryptography, Springer-Verlang, Berlin, 2010
3. Behrouz A Forouzan, Cryptography and Network security, Tata Mc-Graw Hill, New York, 2007.

1. Name of the Department: Mathematics						
2. Course Name	Mathematical Programming	**L**	**T**		**P**	
3. Course Code	17070311	3	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**		**Practical = 0**		

8. Course Description:

This Course consists of different areas likes Non Linear Programming, Integer programming, Dynamic Programming, Network Analysis. Above area define various theorem and Techniques for modeling real world problems and method to find their optimal solution

9. Course Objectives:

The objective of this course to emphasizes the application of Operational Research for solving integer programming, dynamic programming and Network analysis. Throughout this course students are expected to know and understand common and important problems. Student will develop problem modelling and solving skills.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To apply advanced analytical methods to help make better decisions and optimizing system performance.
2. To understand decision maker's behaviours using different optimization tools.
3. To apply different optimization methods as different linear programming and non-linear programming models.
4. To explain research problems in Operations Research human factor is an important component. Without human factor Operations Research study is incomplete.

11. Unit wise detailed content

Unit-1	**Number of lectures = 12**	**Title of the unit: Dynamic Programming**

Deterministic and Probabilistic, Dynamics Programming, Game Theory, Two –Person, Zero – Sum Games, Games with Mixed strategies, Graphical Solution, Solution by linear Programming

Unit – 2	**Number of lectures = 12**	**Title of the unit: Integer Programming**

Branch and Bound Technique, Application to Industrial Problems Optimal product mix and activity levels. Petroleum-Refinery operation, Blending problems. Economic interpretation of dual linear programming problems. Input-Output analysis, Indecomposable and Decomposable economics

Unit – 3	**Number of lectures = 08**	**Title of the unit: Non Linear Programming and Types of Programming**

One and Multi-Variable Unconstrained Optimization, Kuhn-Tucker Condition for Constrained Optimization Quadratic Programming, Separable Programming, Convex Programming , Non Convex Programming

Unit – 4	**Number of lectures = 08**	**Title of the unit: Types of Programming and Network**

		Analysis

Shortest Path Problems, Minimum Spanning Tree problems, Maximum Flow Problems, Minimum Cost Flow Problems, Network Simplex Method, Project Planning and Control with PERT-CPM.

12. Brief Description of self learning / E-learning component

https://www.youtube.com/watch?v=ug7O1lSZyg0

https://www.youtube.com/watch?v=Lt7OZP_F3jY

https://www.youtube.com/watch?v=vUMGvpsb8dc

13. Books Recommended

1. FS Hillier and GJ Leiberman: Introduction to Operation Research(Sixth Edition), McGraw – Hill International Edition.This books comes with a CD containing tutorial software
2. G. Hdley: Linear Programming,Narosa Publishing House 1995
3. G. Hadley, Nonlinear and Dynamic Programming , Addison-Wesley,Reading Mass
4. KantiSwarup, P.K. Guptaand Man Mohan, Operational Research, Sultan chand and Sons New Delhi
5. Taha H.A., Operations Research-An Introduction, PHI (2007)
6. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd, New Delhi.
7. Pant J. C., Introduction to optimization: Operations Research, Jain Brothers (2004)

1. Name of the Department: Mathematics							
2. Course Name	Mathematical Programming Lab	**L**	**T**		**P**		
3. Course Code	17070312	0	0		4		
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()	
7. Total Number of Lectures, Tutorials, Practical							
Lectures = 0		**Tutorials = 0**		**Practical = 52**			

8. Course Description:

Operation Research Lab helps the students to understand the beauty of Math application.

Operations Research is a science of modeling and optimization. It allows you to model real-world problems by using mathematics, statistics, and computers. It provides you tools and theories to solve these real-world problems by finding the optimal solutions to the model's subject to constraints of time, labor, resource, material, and business rules. With Operations Research, people make intelligent decisions to develop and manage their processes.

9. Course Objectives:

This module aims to introduce students to use quantitative methods and techniques for effective decisions making; model formulation and applications that are used in solving decision making problems.

10. Course Outcomes (COs):

By the end of this course, students should be able:

1. To explain necessary decision making problem with the goal of making better decisions.
2. To analyze optimization models and simulate complex real life decision making problems.
3. To implement optimization tools to simulate mathematical model like linear programming models.
4. To use optimization tool for building and solving Linear, Nonlinear, Quadratic, Stochastic, and Integer optimization models faster, easier and more efficient.

11. At least 10 experiments from the following:

1. To determine the area of LLP by Integer Programming
2. To determine the area by Mixed Integer Programming
3. Solve the Dynamic Optimization on Toolbox on any Mathematical Software
4. To solve the feasible area by using Dynamic Programming.
5. To solve the Multi variable constraint by NLPP
6. To solve the Kuhn-Tucker condition by NLPP
7. To solve the Linear Programing Refinery
8. Solve the matrix programming of Game Theory
9. Solve the area by using Quadratic Programming
10. Explain the application of Nonlinear Programming on any Mathematical software
11. Solve the shortest path by using PERT and CPM.
12. Find the Minimum Spanning Tree on MATLAB
13. To solve the feasible area by using the property of Convex set.
14. Solve the project planning by using PERT and CPM

12. E-learning resources

https://www.youtube.com/watch?v=yFprG0iJQUE

https://www.youtube.com/watch?v=z4aMBaTPW3I

https://www.youtube.com/watch?v=kavYLZatz44

https://www.youtube.com/watch?v=M_mpRrGKKMo

13. Books Recommended

1. FS Hillier and GJ Leiberman: Introduction to Operation Research (Sixth Edition), McGraw – Hill International Edition. This book comes with a CD containing tutorial software
2. G. Hdley: Linear Programming, Narosa Publishing House 1995
3. G. Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass
4. Kanti Swarup, P.K. Gupta and Man Mohan, Operational Research, Sultan chand and Sons New Delhi
5. Taha H.A., Operations Research-An Introduction, PHI (2007)
6. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd, New Delhi.
7. Pant J. C., Introduction to optimization: Operations Research, Jain Brothers (2004)

1. Name of the Department: Mathematics						
2. Course Name	Integral Equations	**L**	**T**		**P**	
3. Course Code	17070313	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 40		**Tutorials = 0**		**Practical = 0**		

8. Course Description:

This course contains Fredholm and Volterra integral equations and their solutions using various methods such as Neumann series, resolvent kernels, Euler's equation, variational derivative and invariance of Euler's equations.

9. Course Objectives:

The objectives of this course are to:

1. Give an account of the foundations of Integral Equations and calculus of variations and their applications in mathematics;
2. Solve simple initial and boundary value problems by using several variable calculus.

10. Course Outcomes (COs):

At the end of the course students should be able:

1. To understand different kinds of Fredholm and Voltera Integral equations.
2. To solve integral equation by using different type of methods.
3. To analyze the solution of integral equations by using Hilbert Schmidt theory.
4. To solve many research problems using integral equation in metric spaces, Banach spaces and Hilbert spaces.

11. Unit wise detailed content

Unit-1	**Number of lectures = 12**	**Title of the unit: Definitions, classifications and Eigen functionsof integral equations**

Definitions of integral equations and their classification, Relation between integral and differential equations, Fredholm integral equations of second kind with separable kernels, Reduction to a system of algebraic equations. Eigen values and eigen functions, iterated kernels, iterative scheme for solving Fredholm integral equation of second kind (Neumann series), Resolvent kernel, Application of iterative scheme to Volterra's integral equation of second kind.

Unit – 2	**Number of lectures = 8**	Title of the unit: **Hilbert Schmidt theory**

Hilbert Schmidt theory, symmetric kernels, Orthonormal systems of functions. Fundamental properties of Eigen values and Eigen functions for symmetric kernels. Solution of integral equations by using Hilbert Schmidt theory.

Unit – 3	**Number of lectures = 8**	**Title of the unit: Calculus of Variation**

Introduction to Calculus of Variations, Review of basic multi-variable calculus, constrained maxima and minima, Lagrange multipliers. The Euler-Lagrange equation. Variational problem with moving boundaries: Transversality conditions, one sided variations.

Unit – 4	**Number of lectures = 12**	**Title of the unit: Extremum and Canonical transformations**

General definitions, Jacobi condition, Weirstrass function, Legendre condition, principle of Least action, Lagrange's equation from Hamilton's principle. Canonical transformation, Direct Methods in variational

problems, Ritz, method, Galerkin's method, Collection method and Least square method.
12. Brief Description of self learning / E-learning component
http://nptel.ac.in/courses/111104025/NPTEL-CoV-IE-Solutions.pdf http://nptel.ac.in/courses/111104025/NPTEL-CoV-IE-Problems.pdf http://www.nptelvideos.in/2012/12/calculus-of-variations-and-integral.html
13. Books Recommended
1. A. S. Gupta, Calculus of Variations with Applications, PHI Learning, 2015. 2. Pundir, S and Pundir S., Calculus of Variation, Pragati Prakashan, Fifth edition 2015. 3. R. P. Kanwal, Linear Integral Equation, Theory and Technique, Academic Press New York 1971. 4. M.D. Rai Singhania, Integral Equations, Pragati Prakashan.

1. Name of the Department: Mathematics							
2. Course Name	Integral Equations Lab	**L**	**T**		**P**		
3. Course Code	17070314	0	0		4		
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()	
7. Total Number of Lectures, Tutorials, Practical							
Lectures = 0		**Tutorials = 0**		**Practical = 52**			

8. Course Description:

This course is designed to emphasize the knowledge of Volterra's and Fredholm integral equation. Emphasis is placed on different forms of integral equations. Upon completion, students should be able to write the programs in MATLAB and other software.

9. Course Objectives:

The objectives of this course are to:

1. Give an account of the foundations of Integral Equations and calculus of variations and their applications in mathematics;
2. Solve simple initial and boundary value problems by using several variable calculus.

10. Course Outcomes (COs):

At the end of the course students should be able:

1. To understand different kinds of Fredholm and Voltera Integral equations.
2. To solve integral equation by using different type of methods.
3. To analyze the s Solution of integral equations by using Hilbert Schmidt theory.
4. To solve many research problems using integral equation in metric spaces, Banach spaces and Hilbert spaces.

11. List of Practical's (using any one from , MATLAB, Mathematica)

- To solve Fredholm, Volteraintegral equations.
- To solve variational problems by direct methods.
- To solve the problems by Ritz, method.
- To solve various problems by Galerkin's method.
- To solve the problems using Collection method.
- To solvethe problems using and Least square method.
- To solve Sturm-Liouville problems
- To find the Eigen values and Eigen functions for symmetric kernels
- To find constrained maxima and minima.

12. Books Recommended

1. Jerri, A.J., Introduction to Integral Equations with Applications, 1985.
2. Polyanin, A. D., Manzhirov, A.V., Handbook of Integral Equations, CRC Press, 1995.
3. Kondo, J., Integral Equations, Oxford Applied Mathematics and Computing Scinnce Series, 1992.

1. Name of the Department: Mathematics						
2. Course Name	Introduction to Latex	**L**	**T**		**P**	
3. Course Code	17070315	3	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 40	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course introduces the basic concepts of LaTeX. Participants taking this course will be able to create and design documents in LaTeX and presentations in Beamer with confidence.

9. Course Objectives:

Students will be able to understand

1. To write mathematical formulae
2. To use tabular and array environments within a documents.
3. Classifies the non-linear programming problems
4. To use Theorem, Corollary and other environments.

10. Course Outcomes (COs):

After completing this course students will be able:

1. To use the beamer package to create presentations
2. To use BibTex to maintain bibliography information and to generate a bibliography for a particular document.
3. To analyze different types of documents.
4. To write complex mathematical formulae.

11. Unit wise detailed content

Unit-1	**Number of lectures = 10**	**Title of the unit: Introduction**

This topic introduces the learner to LaTeX, its installation, and different IDEs. The learner creates the first document using LaTeX, organizes content into sections using article and book class of LaTeX.

Unit – 2	**Number of lectures = 10**	**Title of the unit: Styling Pages**

In this topic, the session starts by reviewing different paper sizes, examines packages, formats the page by setting margins, customizing header and footer, changing the page orientation, dividing the document into multiple columns. The topic ends with reading different types of error messages.

Unit – 3	**Number of lectures = 10**	**Title of the unit: Formatting Content**

This topic concentrates on formatting text (styles, size, alignment), adding colors to text and entire page, and adding bullets and numbered items. It concludes by explaining the process of writing complex mathematics.

Unit – 4	**Number of lectures = 10**	**Title of the unit: Tables and Images**

The topic starts by creating basic tables, adding simple and dashed borders, merging rows and columns, and handling situations where a table exceeds the size of a page. The sessions then continue to add an

image, explore different properties like rotate, scale, etc.
12. Brief Description of self learning / E-learning component
https://www.youtube.com/watch?v=0ivLZh9xK1Q&list=PL1D4EAB31D3EBC449 **https://www.youtube.com/watch?v=bCumVPGR4ts&list=PL1D4EAB31D3EBC449&index=2** **https://www.youtube.com/watch?v=kefvRACdXHs&list=PL1D4EAB31D3EBC449&index=3**
13. Books Recommended
1. LaTex Tutorial: A primary by Indian Tex users group 2. LaTeX for Complete Novices by Nicola L. C. Talbot 3. More Math into Latex 4th Edition by George Gratzer