10 YEARS OF UNIVERSITY RECOGNITION

20 YEARS OF ACADEMIC EXCELLENCE

REVA UNIVERSITY

Bengaluru, India

SCHOOL OF APPLIED SCIENCES

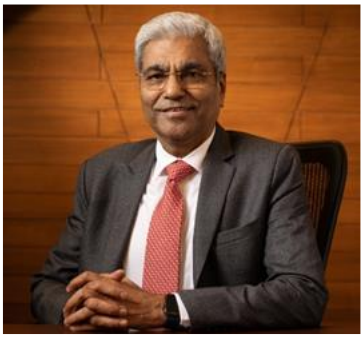
M.Sc.- Mathematics

HANDBOOK: 2021-23

Chancellor's Message

"Education is the most powerful weapon which you can use to change the world."

- Nelson Mandela.



There was a time when survival depended on just the realization of physiological needs. We are indeed privileged to exist in a time when 'intellectual gratification' has become indispensable. Information is easily attainable for the soul that is curious enough to go look for it. Technological boons enable information availability anywhere anytime. The difference, however, lies between those who look for information and those who look for knowledge.

It is deemed virtuous to serve seekers of knowledge and as educators it is in the ethos at REVA University to empower every learner who chooses to enter our portals. Driven by our founding philosophy of 'Knowledge is Power', we believe in building a community of perpetual learners by enabling them to look beyond their abilities and achieve what they assumed impossible.

India has always been beheld as a brewing pot of unbelievable talent, acute intellect and immense potential. All it takes to turn those qualities into power is a spark of opportunity. Being at a University is an exciting and rewarding experience with opportunities to nurture abilities, challenge cognizance and gain competence.

For any University, the structure of excellence lies in the transitional abilities of its faculty and its facility. I'm always in awe of the efforts that our academic board puts in to develop the team of subject matter experts at REVA. My faculty colleagues understand our core vision of empowering our future generation to be ethically, morally and intellectually elite. They practice the art of teaching with a student-centered and transformational approach. The excellent infrastructure at the University, both educational and extra-curricular, magnificently demonstrates the importance of ambience in facilitating focused learning for our students.

A famous British politician and author from the 19th century - Benjamin Disraeli, once said 'A University should be a place of light, of liberty and of learning'. Centuries later this dictum still inspires me and I believe, it takes team-work to build successful institutions. I welcome you to REVA University to join hands in laying the foundation of your future with values, wisdom and knowledge.

Dr. P. Shyama Raju
The Founder and Hon'ble Chancellor, REVA University

Vice-Chancellor's Message

The last two decades have seen a remarkable growth in higher education in India and across the globe. The move towards inter-disciplinary studies and interactive learning have opened up several options as well as created multiple challenges. India is at a juncture where a huge population of young crowd is opting for higher education. With the tremendous growth of privatization of education in India, the major focus is on creating a platform for quality in knowledge enhancement and bridging the gap between academia and industry.

A strong believer and practitioner of the dictum "Knowledge is Power", REVA University has been on the path of delivering quality education by developing the young human resources on the foundation of ethical and moral values, while boosting their leadership qualities, research culture and innovative skills. Built on a sprawling 45 acres of green campus, this 'temple of learning' has excellent and state-of-the-art infrastructure facilities conducive to higher teaching-learning environment and research. The main objective of the University is to provide higher education of global standards and hence, all the programs are designed to meet international standards. Highly experienced and qualified faculty members, continuously engaged in the maintenance and enhancement of student-centric learning environment through innovative pedagogy, form the backbone of the University.

All the programs offered by REVA University follow the Choice Based Credit System (CBCS) with Outcome Based Approach. The flexibility in the curriculum has been designed with industry-specific goals in mind and the educator enjoys complete freedom to appropriate the syllabus by incorporating the latest knowledge and stimulating the creative minds of the students. Bench marked with the course of studies of various institutions of repute, our curriculum is extremely contemporary and is a culmination of efforts of great think-tanks - a large number of faculty members, experts from industries and research level organizations. The evaluation mechanism employs continuous assessment with grade point averages. We believe sincerely that it will meet the aspirations of all stakeholders – students, parents and the employers of the graduates and postgraduates of REVA University.

At REVA University, research, consultancy and innovation are regarded as our pillars of success. Most of the faculty members of the University are involved in research by attracting funded projects from various research level organizations like DST, VGST, DBT, DRDO, AICTE and industries. The outcome of the research is passed on to students through live projects from

industries. The entrepreneurial zeal of the students is encouraged and nurtured through EDPs and EACs.

REVA University has entered into collaboration with many prominent industries to bridge the gap between industry and University. Regular visits to industries and mandatory internship with industries have helped our students. REVA University has entered into collaboration with many prominent industries to bridge the gap between Industry and University. Regular visits to Industries and mandatory internship with industries have helped our students become skilled with relevant to industry requirements. Structured training programs on soft-skills and preparatory training for competitive exams are offered here to make students more employable. 100% placement of eligible students speaks the effectiveness of these programs. The entrepreneurship development activities and establishment of "Technology Incubation Centers" in the University extend full support to the budding entrepreneurs to nurture their ideas and establish an enterprise.

With firm faith in the saying, "Intelligence plus character –that is the goal of education" (Martin Luther King, Jr.), I strongly believe REVA University is marching ahead in the right direction, providing a holistic education to the future generation and playing a positive role in nation building. We reiterate our endeavor to provide premium quality education accessible to all and an environment for the growth of over-all personality development leading to generating "GLOBAL PROFESSIONALS".

Welcome to the portals of REVA University!

Dr. M. Dhanamjaya
Vice-Chancellor, REVA University

Director's Message

The M.Sc. Mathematics programme aims to build strong foundations in core areas of higher mathematics in both the pure and applied areas. It is meant for students who would typically take up careers involving mathematical research or mathematical skills – in academia or in industry. The training imparted to the students helps them master the art of problem solving, developing logical reasoning and computational capabilities which are essential traits in all walks of life. Additionally, the knowledge of mathematical modelling and computational training which the students acquire during the programme makes them highly sought after. In keeping with the demands of industry and academia, the syllabus is updated regularly, with inputs taken from various stakeholders including students, alumni, and parents at different stages of the preparation of the syllabus. The curriculum is carefully designed to meet the NET and GATE examination syllabus and industry trends. Curriculum has good mix of foundation courses, hardcore courses, soft-core courses, practical's, and projects along with open electives, soft skill and skill development courses. The curriculum caters to and has relevance to local regional, national and global developmental needs. Maximum number of courses are integrated with crosscutting issues with relevant to professional ethics, Gender, Human values, Environment and sustainability.

Since the beginning of REVA University, the Mathematics Department is involved in implementing best practices in various dimensions such as academics, research, outreach activities, student development programs, student centric learning, student competitions, skill enhancement activities, motivation for competitive exams, mini projects, major projects, multidisciplinary projects, industry visits, technical talks by industry and academicians, certification programs, etc. Individual students are taken care by a strong mentoring system wherein faculty members are not only allotted as mentors to students, but also they will act as local guardians and they will have constant follow up with mentees in regard to academic and personal issues till students complete the degree.

This handbook provides an outline of regulations for master's degree, scheme of instruction, and detailed syllabus. I am sure the students choosing MSc Mathematics at REVA University will enjoy the curriculum, teaching and learning environment, the vast infrastructure and the experienced teachers' involvement and guidance. We will strive to provide all needed comfort and congenial environment for their studies. I wish all students a pleasant stay at REVA and grand success in their career.

Prof.Shilpa BR

Deputy Director, SoAS

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RUKMINI EDUCATIONAL CHARITABLE TRUST

It was the dream of late Smt. Rukmini Shyama Raju to impart education to millions of underprivileged children as she knew the importance of education in the contemporary society. The dream of Smt. Rukmini Shyama Raju came true with the establishment of Rukmini Educational Charitable Trust (RECT), in the year 2002. Rukmini Educational Charitable Trust(RECT) is a Public Charitable Trust, set up in 2002 with the objective of promoting, establishing and conducting academic activities in the fields of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology, among others. In furtherance of these objectives, the Trust has set up the REVA Group of Educational Institutions comprising of REVA Institute of Technology & Management (RITM), REVA Institute of Science and Management (RISM), REVA Institute of Management Studies (RIMS), REVA Institute of Education (RIE), REVA First Grade College (RFGC), REVA Independent PU College at Kattigenahalli, Ganganagar and Sanjaynagar and now REVA University. Through these institutions, the Trust seeks to fulfil its vision of providing world class education and create abundant opportunities for the youth of this nation to excel in the areas of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology.

Every great human enterprise is powered by the vision of one or more extraordinary individuals and is sustained by the people who derive their motivation from the founders. The Chairman of the Trust is Dr. P. Shyama Raju, a developer and builder of repute, a captain of the industry in his own right and the Chairman and Managing Director of the DivyaSree Group of companies. The idea of creating these top notched educational institutions was born of the philanthropic instincts of Dr. P. Shyama Raju to do public good, quite in keeping with his support to other socially relevant charities such as maintaining the Richmond road park, building and donating a police station, gifting assets to organizations providing accident and trauma care, to name a few.

The Rukmini Educational Charitable Trust drives with the main aim to help students who are in pursuit of quality education for life. REVA is today a family of ten institutions providing education from PU to Post Graduation and Research leading to PhD degrees. REVA has well qualified experienced teaching faculty of whom majority are doctorates. The faculty is supported by committed administrative and technical staff. Over 15,000+ students study various courses across REVA's three campuses equipped with exemplary state-of-the-art infrastructure and conducive environment for the knowledge driven community.

ABOUT REVA UNIVERSITY

REVA University has been established under the REVA University Act, 2012 of Government of Karnataka and notified in Karnataka State Gazette No. 80 dated 27thFebruary, 2013. The University is empowered by UGC to award degrees any branch of knowledge under Sec.22 of the UGC Act. The University is a Member of Association of Indian Universities, New Delhi. The main objective of the University is to prepare students with knowledge, wisdom, and patriotism to face the global challenges and become the top leaders of the country and the globe in different fields.

REVA University located in between Kempegowda International Airport and Bangalore city, has a sprawling green campus spread over 45 acres of land and equipped with state-of-the-art infrastructure that provide conducive environment for higher learning and research. The REVA campus has well equipped laboratories, custom-built teaching facilities, fully air-conditioned library and central computer centre, the well-planned sports facility with cricket ground, running track & variety of indoor and outdoor sports activities, facilities for cultural programs. The unique feature of REVA campus is the largest residential facility for students, faculty members and supportive staff.

REVA consistently ranked as one of the top universities in various categories because of the diverse community of international students and its teaching excellence in both theoretical and technical education in the fields of Engineering, Management, Law, Science, Commerce, Arts, Performing Arts, and Research Studies. REVA offers 28 Undergraduate Programmes, 22 Full-time and 2 Part-time Postgraduate Programmes, 18 Ph. D Programmes, and other Certificate/ Diploma/Postgraduate Diploma Programmes in various disciplines.

The curriculum of each programme is designed with a keen eye for detail by giving emphasis on hands-on training, industry relevance, social significance, and practical applications. The University offers world-class facilities and education that meets global standards.

The programs being offered by the REVA University are well planned and designed after detailed study with emphasis with knowledge assimilation, applications, global job market and their social relevance. Highly qualified, experienced faculty and scholars from reputed universities / institutions, experts from industries and business sectors have contributed in preparing the scheme of instruction and detailed curricula for this program. Greater emphasis on practice in respective areas and skill development to suit to respective job environment has been given while designing the curricula. The Choice Based Credit System and Continuous

Assessment Graded Pattern (CBCS – CAGP) of education has been introduced in all programs to facilitate students to opt for subjects of their choice in addition to the core subjects of the study and prepare them with needed skills. The system also allows students to move forward under the fast track for those who have the capabilities to surpass others. These programs are taught by well experienced qualified faculty supported by the experts from industries, business sectors and such other organizations. REVA University has also initiated many supportive measures such as bridge courses, special coaching, remedial classes, etc., for slow learners so as to give them the needed input and build in them confidence and courage to move forward and accomplish success in their career. The University has also entered into MOUs with many industries, business firms and other institutions seeking their help in imparting quality education through practice, internship and also assisting students' placements.

REVA University recognizing the fact that research, development and innovation are the important functions of any university has established an independent Research and Innovation division headed by a senior professor as Dean of Research and Innovation. This division facilitates all faculty members and research scholars to undertake innovative research projects in engineering, science & technology and other areas of study. The interdisciplinary-multidisciplinary research is given the top most priority. The division continuously liaisons between various funding agencies, R&D Institutions, Industries and faculty members of REVA University to facilitate undertaking innovative projects. It encourages student research projects by forming different research groups under the guidance of senior faculty members. Some of the core areas of research wherein our young faculty members are working include Data Mining, Cloud Computing, Image Processing, Network Security, VLSI and Embedded Systems, Wireless Censor Networks, Computer Networks, IOT, MEMS, Nano- Electronics, Wireless Communications, Bio-fuels, Nano-technology for coatings, Composites, Vibration Energies, Electric Vehicles, Multilevel Inverter Application, Battery Management System, LED Lightings, Renewable Energy Sources and Active Filter, Innovative Concrete Reinforcement, Electro Chemical Synthesis, Energy Conversion Devices, Nano-structural Materials, Photo-electrochemical Hydrogen generation, Pesticide Residue Analysis, Nano materials, Photonics, Nana Tribology, Fuel Mechanics, Operation Research, Graph theory, Strategic Leadership and Innovative Entrepreneurship, Functional Development Management, Resource Management and Sustainable Development, Cyber Security, General Studies, Feminism, Computer Assisted Language Teaching, Culture Studies etc.

The REVA University has also given utmost importance to develop the much required skills through variety of training programs, industrial practice, case studies and such other activities that induce the said skills among all students. A full-fledged Career Development and Placement

(CDC) department with world class infrastructure, headed by a dynamic experienced Professor& Dean, and supported by well experienced Trainers, Counsellors and Placement Officers.

The University also has University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director facilitating skill related training to REVA students and other unemployed students. The University has been recognised as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal VikasYojana. The Centre conducts several add-on courses in challenging areas of development. It is always active in facilitating student's variety of Skill Development Training programs.

The University has collaborations with Industries, universities abroad, research institutions, corporate training organizations, and Government agencies such as Florida International University, Okalahoma State University, Western Connecticut University, University of Alabama, Huntsville, Oracle India Ltd, Texas Instruments, Nokia University Relations, EMC^2, VMware, SAP, Apollo etc, to facilitate student exchange and teacher–scholar exchange programs and conduct training programs. These collaborations with foreign universities also facilitates students to study some of the programs partly in REVA University and partly in foreign university, viz, M.S in Computer Science one year in REVA University and the next year in the University of Alabama, Huntsville, USA.

The University has also given greater importance to quality in education, research, administration and all activities of the university. Therefore, it has established an independent Internal Quality division headed by a senior professor as Dean of Internal Quality. The division works on planning, designing and developing different quality tools, implementing them and monitoring the implementation of these quality tools. It concentrates on training entire faculty to adopt the new tools and implement their use. The division further works on introducing various examination and administrative reforms.

To motivate the youth and transform them to become innovative entrepreneurs, successful leaders of tomorrow and committed citizens of the country, REVA organizes interaction between students and successful industrialists, entrepreneurs, scientists, and such others from time to time. As a part of this exercise great personalities such as Bharat Ratna Prof. C. N. R. Rao, a renowned Scientist, Dr. N R Narayana Murthy, Founder and Chairman and Mentor of Infosys, Dr. K Kasturirangan, Former Chairman ISRO, Member of Planning Commission, Government of India, Dr.Balaram, Former Director IISc., and noted Scientist, Dr. V S Ramamurthy, Former Secretary, DST, Government of India, Dr. V K Aatre, noted Scientist and former head of the DRDO and Scientific Advisor to the Ministry of Defence Dr.Sathish Reddy, Scientific Advisor, Ministry of Defence, New Delhi and many others have accepted our invitation and blessed our students and faculty members by their inspiring addresses and interaction.

REVA organises various cultural programs to promote culture, tradition, ethical and moral values to our students. During such cultural events, the students are given opportunities to unfold their hidden talents and motivate them to contribute innovative ideas for the progress of the society. One of such cultural events is REVAMP conducted every year. The event not only gives opportunities to students of REVA but also students of other Universities and Colleges. During three days of this mega event students participate in debates, Quizzes, Group discussion, Seminars, exhibitions, and variety of cultural events. Another important event is Shubha Vidaaya, - Graduation Day for the final year students of all the programs, wherein, the outgoing students are felicitated and are addressed by eminent personalities to take their future career in a right spirit, to be the good citizens and dedicate themselves to serve the society and make a mark in their respective spheres of activities. During this occasion, the students who have achieved top ranks and won medals and prizes in academic, cultural and sports activities are also recognised by distributing awards and prizes. The founders have also instituted medals and prizes for sports achievers every year. The physical education department conducts regular yoga class is every day to students, faculty members, administrative staff and their family members and organizes yoga camps for villagers around.

Vision

REVA University aspires to become an innovative university by developing excellent human resources with leadership qualities, ethical and moral values, research culture and innovative skills through higher education of global standards

Mission

- To create excellent infrastructure facilities and state-of-the-art laboratories and incubation centres
- To provide student-centric learning environment through innovative pedagogy and education reforms
- To encourage research and entrepreneurship through collaborations and extension activities
- To promote industry-institute partnerships and share knowledge for innovation and development
- To organize society development programs for knowledge enhancement in thrust areas
- To enhance leadership qualities among the youth and enrich personality traits, promote patriotism and moral values.

Objectives

- Creation, preservation and dissemination of knowledge and attainment of excellence in different disciplines
- Smooth transition from teacher - centric focus to learner - centric processes and activities
- Performing all the functions of interest to its major constituents like faculty, staff, students and the society to reach leadership position.
- Developing a sense of ethics in the University and Community, making it conscious of its obligations to the society and the nation
- Accepting the challenges of globalization to offer high quality education and other services in a competitive manner.

ABOUT THE SCHOOL OF APPLIED SCIENCES

The School of Applied Sciences offers graduate and post graduate programs in Biotechnology, Biochemistry, Chemistry, Physics and Mathematics which are incredibly fascinating. It aims to attract talented youth and train them to acquire knowledge and skills useful to industrial sectors, research laboratories, and educational institutions. The School presently offers M.Sc. degree programs in Bio-Chemistry, Bio-Technology, Chemistry, Physics, Mathematics and B Sc with various combinations viz, Physics Chemistry and Mathematics, Mathematics , Physics and Statistics, Mathematics Statistics and Computer Science, and Biology Mathematics & Computer Science and also Post Graduate Diploma in Clinical Research Management. The School also facilitates research leading to PhD in Biotechnology, Biochemistry, Physics, Chemistry, Mathematics, and related areas of study.

The School of Applied Sciences is shouldered by well qualified, experienced, and highly committed faculty. The state-of-the-art infrastructure digital classrooms, well equipped laboratories, conference rooms and the serene academic atmosphere at REVA University will enhance the transfer as well as creation of knowledge. The school provides an interactive, collaborative peer tutoring environment that encourages students to break down complex problems and develop strategies for finding solutions across a variety of situations and disciplines. The school aims to develop a learning community of critical thinkers who serves as models of innovative problems solving in the university environment to enrich their academic and professional careers.

Vision

To nurture intellect, creativity, character, and professionalism among students and impart contemporary knowledge in various branches of Chemical, Biological, Physical and Mathematical Sciences that are socially relevant and transform them to become global citizens.

Mission

To achieve excellence in studies and research through pedagogy and support interface between industry and academia.

ABOUT THE DEPARTMENT

The Department of Mathematics is one of the innovative and rich blends of experienced faculty who are well-qualified in various aspects of Mathematics skills. Applying a multi-disciplinary research and teaching methods, the department strongly believes in finding mathematical solutions for various social-economic, technological, and work-related processes and challenges. With 31 faculty members representing major areas of Mathematics, the department is at the forefront of cutting-edge research as well as teaching and innovation.

The Department of Mathematics offers a master's programme in Mathematics and Ph.D. in Mathematics. Nearly 20 Scholars have been awarded Ph.D. degrees and more than 175 articles published in Web of Science, Scopus, and UGC recognized Journals in the last five years. The department is also actively involved in administering the University's undergraduate and postgraduate programmes for Mathematics courses in various Schools of the university. Our excellent and highly experienced faculty, with qualifications from premier institutions and expertise in diverse fields including Operations Research, Graph theory, Fuzzy sets and fuzzy logic, Fluid Dynamics, Optimization Techniques and Artificial intelligence. Several members of the faculty are acting as a reviewer on peer reviewed National and International Journals.

The department is committed to outstanding graduate training to produce leading scholars in various fields of Mathematics. Since its inception, the department moulds Ph. D graduates to carry out challenging research problems which have wide ranging industrial and social implications. Students are provided with ample opportunities to improve their research, teach courses, and participate in conferences/seminars.

BOS MEMBERS

Sl. No.	Name, Designation & Affiliation	Status	Correspondence Address
1	Dr. Harish Babu G A REVA University	Chair Person	Assistant Director, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
2	Prof. Dr. A. S. Vasudeva Murthy TIFR-CIM	Member (External)	Associate Professor, TIFR-CIM, Yelahanka, Bangalore.
3	Fr Joseph Varghese Kureethara CMI, Christ University	Member (External)	Associate Professor, Department of Mathematics, Christ University, Hosur Road, Bangalore-560029
4	Sandeepa, M.S, Sr. Data Scientist, Sapient	Member (External)	Sr. Data Scientist, Sapient Consultancy, Bangalore
5	Dr. Hanumagouda B N	Member (Internal)	Professor, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
6	Dr. R. Murugesan	Member (Internal)	AssociateProfessor, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
7	Dr. Vishu Kumar M	Member (Internal)	Professor, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
8	Dr. Uday Kumar K N	Member (Internal)	Associate Professor, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
9	Dr. Naga Maruthi Kumari	Member (Internal)	Associate Professor, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
10	Dr.Raju B.T	Member (Internal)	Associate Professor, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
11	Dr. Madhusudhana Zalki	Member (Internal)	Professor, School of Applied Sciences-Mathematics, REVA University, Rukmini Knowledge Park, Yelahanka, Bangalore - 560 064
12	Miss. Mamatha, OG Health care	Alumni	OG Healthcare, Infosense Technologies Private Limited, Bangalore-560094
13	Miss. Aishwarya	Current Student	3rd sem M.Sc., Mathematics, School of Applied Sciences, REVA University, Rukmini Knowledge Park, Bangalore 560 064

M.Sc., (Mathematics) Program Overview

Higher education across the globe is opening doors of its academic disciplines to the real-world experiences. The disciplinary legitimacy is under critical review. Trans-border mobility and practice learning are being fore grounded as guiding principles. Interactive learning, bridging disciplines and facilitating learners to gain different competencies through judicious management of time is viewed as one of the greatest and fascinating priorities and challenges today.

The M.Sc. Mathematics is designed on keeping in view the current situation and possible future developments, both at national and global levels. This course is designed to give greater emphasis on research and competitive examinations. There are a number of courses providing knowledge in specialized areas of Abstract Algebra, Linear Algebra, Real and Complex Analysis, Topology, Functional Analysis, Mathematical Statistics, Optimization, computational techniques, R-tools, and Python Program etc., facilitating students to choose specialized areas of their interest. Adequate attention is given to provide students with basic concepts of analysis and modern computation techniques to be used, and knowledge on application of such concepts in practical field. The project, being part of the curriculum will certainly provide students with experience of research and practical exposure in working environment.

The L: T: P structure of teaching and learning under Choice Based Credit System (CBCS), and Continuous Assessment Grading Pattern (CAGP) would certainly help our students learn and build competencies needed in this knowledge-based society.

This handy document containing a brief information about M.Sc. Mathematics, scheme of instruction, course content, CBCS-CAGP regulations and its advantages will serve as a guiding path to students to move forward in a right direction. It would mould them with knowledge, skill, and ethical values to face the challenges of this competitive world with greater confidence in becoming proud citizens.

Program Educational Objectives (PEOs)

The program educational objectives of Mathematics of REVA University are to prepare the graduates to

PEO-1	Serve as a tutor in mathematics and perform with effective communication and ethics.
PEO-2	Carryout research in the areas of pure and applied mathematics and publish work as individual or in a team.
PEO-3	Provide consultancy in the advanced areas of mathematics with lifelong learning attitude.

Program Outcomes (POs):

PO-1	**Science knowledge**: Demonstrate the skills in the areas of mathematics and applied areas.
PO-2	**Problem analysis**: Apply mathematical skills to formulate, solve and interpret complex problems through mathematical models.
PO-3	**Conduct investigations of complex problems**: Comprehend, analyze, model, and solve complex problems based on structured and relevant reasoning.
PO-4	**Modern tool usage:** Use latest computer techniques as a tool to carry out scientific investigations and develop new variants of the acquired methods and problems related to environment and society.
PO-5	**Ethics:** Exhibit professional and ethical responsibility.
PO-6	**Individual and teamwork**: Encourage collaborative learning through group activities and hands-on learning.
PO-7	**Communication**: Communicate mathematical ideas with clarity and coherence, both written and verbally.
PO-8	**Life-long learning**: Recognize the need to expertise in the areas of mathematics by self-up gradation through lifelong learning.

Program Specific Outcomes (PSO)

After successful completion of the programme, the graduates shall be able to

PSO-1	Demonstrate the knowledge of Mathematical Analysis, Algebra, Statistics, Optimization and Computational Mathematics.
PSO-2	Analyse and solve problems in Mathematical Analysis, Algebra, Statistics, Optimization and Computational Mathematics.
PSO-3	Use tools and techniques for addressing the problems of Industry, Organizations, and environment in Mathematical Analysis, Algebra, Statistics, Optimization and Computational Mathematics.

REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Postgraduate Degree programs- 2020

(Framed as per the provisions under Section 35 (ii), Section 7 (x) and Section 8 (xvi) & (xxi) of the REVA University Act, 2012)

1. Title and Commencement:

1.1.1. These Regulations shall be called the **"REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Post Graduate Degree Programs- 2020".**

1.2. These Regulations shall come into force from the date of assent of the Chancellor.

2. The Programs:

The following programs and all Graduate Degree programs to be instituted and introduced in REVA University in coming years shall follow these regulations.

M.Sc in:

Biotechnology
Biochemistry
Chemistry
Physics
Mathematics

3. Definitions:

Course: Every course offered will have three components associated with the teaching-learning process of the course, namely:

(i) L= Lecture (ii) T= Tutorial (iii) P=Practice; where:

L stands for **Lecture** session consisting of classroom instruction.

T stands for **Tutorial** session consisting participatory discussion / selfstudy/ desk work/ brief seminar presentations by students and such other novel methods that make a student to absorb and assimilate more effectively the contents delivered in the Lecture classes.

P stands for **Practice** session and it consists of Hands on Experience / Laboratory Experiments / Field Studies / Case Studies that equip students to acquire the much required skill component.

4. Courses of study and Credits:

4.1. The study of various subjects in M. Sc., degree program are grouped under various courses. Each of these course carries credits which are based on the number of hours of teaching and learning.

4.1.1. In terms of credits, every one hour session of L amounts to 1 credit per Semester and a minimum of two hour session of T or P amounts to 1 credit per Semester over a period of one Semester of 16 weeks for teaching-learning process.

4.1.2. The total duration of a semester is 20 weeks inclusive of semester-end examination.

4.1.3. A course shall have either or all the four components. That means a course may have only lecture component, or only practical component or combination of any two or all the three components.

4.1.4. The concerned BoS will assign Credit Pattern for every course based on the requirement. However, generally, courses can be assigned with 1-4 Credits depending on the size of the course.

4.1.5. Different **Courses of Study** are labelled and defined as follows:

Core Course:

A course which should compulsorily be studied by a candidate as a core-requirement is termed as a Core course. The CORE courses of Study are of THREE types, viz – (i) Hard Core Course, and (ii) Soft Core Course, (iii) Open elective Course.

a. Hard Core Course (HC):

The **Hard-Core Course** is a Core Course in the main branch of study and related branch(es) of study, if any that the candidates have to complete compulsorily.

b. Soft Core Course (SC):

A Core course may be a **Soft Core** if there is a choice or an option for the candidate to choose a course from a pool of courses from the main branch of study or from a sister/related branch of study which supports the main branch of study.

c. Open Elective Course:

An elective course chosen generally from other discipline / subject, with an intention to seek exposure to the basics of subjects other than the main discipline the student is studying is called an O**pen Elective Course.**

d. Project Work / Dissertation:

Project work / Dissertation work is a special course involving application of knowledge in solving / analysing /exploring a real-life situation / difficult problem. A project work carrying **FOUR or SIX** credits is called **Minor Project** work / **Dissertation.** A project work of **EIGHT, TEN, TWELVE or SIXTEEN** credits is called **Major Project** work / **Dissertation**. **A Project work may be a hard core, or a Soft Core as decided by the BoS / concerned.**

5. Eligibility for Admission:

Passed Bachelor's Degree of 3 years with Mathematics as major / optional subject with 45% marks (40% in case of candidate belonging to SC/ST category) of marks in aggregate of any recognized/institution or any other qualification recognized as equivalent there to.

6. Scheme, Duration and Medium of Instructions:

6.1. M.Sc., degree program is of 4 semesters - 2 years duration. A candidate can avail a maximum of 6 semesters (3 years) including blank semesters, if any to successfully complete M. Sc. degree. Whenever a candidate opts for blank semester, he/she must study the prevailing courses offered by the School when he/she resumes his/her studies.

6.2. The medium of instruction shall be English.

7. Credits and Credit Distribution:

7.1. A candidate has to earn 90 credits for successful completion of Two-Year Postgraduate degree with a distribution of credits for different courses as given in Table - 1 given below:

Table-1

Credits and Credit Distribution for Two Year Post Graduate degree programs

Course Type	**Credits for Two Year (4 Semesters) Post Graduate Degree Programs**
Hard Core Course	A minimum of 60 but not exceeding 70
Soft Core Course	A minimum of 14 but not exceeding 30
Open Elective	A minimum of 04
RULO	A minimum of 2 but not exceeding 8
Total	**90**

7.2. The concerned BOS based on the credits distribution pattern given above shall prescribe the credits to various types of courses and shall assign title to every course including project work, practical work, field work, self-study elective, as **Hard Core (HC) or Soft Core (SC) or Open Elective (OE)**.

7.3. Every course including project work, practical work, field work, self-study elective should be entitled as Hard Core (HC) or Soft Core (SC) or Open Elective (OE) by the BoS concerned.

However, following shall be the
RULO (REVA Unique Learning Offerings) courses with credits mentioned against them, common to all branches of study. However, the BOS of respective program/ discipline shall decide about the total credits for RULO courses.

RULO Courses		
Sl. No.	Course Title	Number of Credits

1	Sports, Yoga, Music, Dance, Theatre	2
2	MOOC / Swayam/ Coursera/Internship /Soft Skill Training	6
	Total	8

7.4. The concerned BOS shall specify the desired Program Objectives, Program Educational Objectives, Program Specific Outcomes and Course Outcomes while preparing the curriculum of a particular program.

7.5. A candidate can enrol for a maximum of 30 credits and a minimum of 20 credits per Semester. However, he / she may not successfully earn a maximum of 30 credits per semester. This maximum of 30 credits does not include the credits of courses carried forward by a candidate.

7.6. Only such full time candidates who register for a minimum prescribed number of credits in each semester from I semester to IV semester and complete successfully 96 credits in 4 successive semesters shall be considered for declaration of Ranks, Medals, Prizes and are eligible to apply for Student Fellowship, Scholarship, Free ships, and such other rewards / advantages which could be applicable for all full time students and for hostel facilities.

8. Add-on Proficiency Certification / Diploma:

8.1 Add- on Proficiency Certification:

To acquire Add on Proficiency Certification a candidate can opt to complete a minimum of 4 extra credits either in the same discipline /subject or in different discipline / subject in excess to 90 credits for the Two Year Post Graduate degree programs.

8.2 Add on Proficiency Diploma:

To acquire Add on Proficiency Diploma, a candidate can opt to complete a minimum of 18 extra credits either in the same discipline /subject or in different discipline / subject in excess to 96 credits for the Two Year Post Graduate degree programs.

The Add on Proficiency Certification / Diploma so issued to the candidate contains the courses studied and grades earned.

9. Assessment and Evaluation

I. Each course is assessed for a total weight of 100%. Out of the total 100% weight; 50% weight is for Continuous Internal Assessment (CIA or IA) and the remaining 50% for the Semester End Examination (SEE). This is applicable for theory, laboratory, workshop, studio and any such courses.

II. Out of 50% weight earmarked for Internal Assessment (IA)- 15% for test-1, 15% for test- 2 and 20% for Assignments and this is applicable for theory based courses .

III. The tests and assignments are conducted as per the semester academic calendar provided by the University.

The details as given in the table

Component	**Description**	**Conduction**	**Weight Percentage**
C1	**Test-1: IA1**	**6th week from the starting date of semester**	**15**
	Test-2: IA2	**12th week from the starting date of semester**	**15**
C2	**1 Assignment**	**7th week**	**10**
	2 Assignment	**13th week**	**10**

C3	**SEE including practical**	**between 17th Week-20th Week**	**50**
Results to be Announced			**By the end of 21st Week**

Note: IA or CIA includes C1 and C2

Each test must be conducted for a duration of 60 minutes, setting the test question paper for a maximum of 30 marks. The final examination must be conducted for a duration of 3 hours and the question paper must be set for a maximum of 100 marks.

IV. Students are required to complete courses like technical skills, placement related courses, Open electives and any such value addition or specialized courses through online platforms like SWAYAM/NPTEL/Any other reputed online education aggregator. Students are required to choose the courses on the advice of their course coordinator/Director and required to submit the course completion certificate along with percentage of marks/grade scored in the assessment conducted by the online education aggregator. If the online education aggregator has issued a certificate along with the grade or marks scored to students, such courses will be considered for SGPA calculations, in case the aggregator has issued only a certificate and not marks scored, then such courses will be graded through an examination by concerned School, in case, if grading is not possible, students will be given a pass grade and award the credit and the credits will not be considered for SGPA calculations. The Online/MOOCs courses will not have continuous internal assessment component.

Such of those students who would like to discontinue with the open elective course that they have already registered for earning required credits can do so, however, they need to complete the required credits by choosing an alternative open elective course.

V. Setting question paper and evaluation of answer scripts:

i. For SEE, three sets of question papers shall be set for each theory course out of which two sets will be by the internal examiners and one set will be by an external examiner. In subsequent years by carrying forward the unused question papers, an overall three sets of question papers should be managed and depending on the consumption of question papers either internal or external examiner be called for

setting the question paper to maintain an overall tally of 3 papers with the conditioned mentioned earlier. The internal examiner who sets the question paper should have been course tutor.

ii. The Chairman of BoE shall get the question papers set by internal and external examiners.

iii. The Board of Examiners shall scrutinize and approve the question papers and scheme of valuation. It is the responsibility of the BoE to see that all questions contained in the question paper are within the prescribed syllabus of the concerned course.

iv. There shall be single valuation for all theory papers by internal examiners. However, there shall be moderation by the external examiner who has the subject background. In case no external examiner with subject background is available, a senior faculty member within the discipline shall be appointed as moderator.

v. The SEE examination for Practical work / Field work / Project work/Internship will be conducted jointly by internal and external examiners as detailed below: However, the BoE on its discretion can also permit two internal examiners.

vi. If a course is fully of (L=0):T:(P=0) type or a course is partly P type i.e, (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

10. Evaluation of Practical's and Minor Project / Major Project / Dissertation:

10.1. A practical examination shall be assessed based on:

a) Knowledge of relevant processes.
b) Skills and operations involved.
c) Results / products including calculation and reporting.

10.2. In case a course is fully of P type (L=0: T=0: P=4), the performance of a candidate shall be assessed for a maximum of 100 marks as explained below:

a) Continuous Internal assessment (CIA) = 50 marks.
b) Semester end practical examination (SEE) = 50 marks.

The 25 marks for continuous assessment shall further be allocated as under (IA or CIA):

i	Conduction of regular practical throughout the semester	20 marks
ii	Maintenance of lab records /industry reports/SDP reports	15 marks
iii	Laboratory test and viva	15 marks
	Total	50 marks

The 50 marks meant for Semester End Examination, shall be allocated as under:

i	Conduction of semester end practical examination	30 marks
ii	Write up about the experiment / practical conducted	10 marks
iii	Viva Voce	10 marks
	Total	50 marks

10.3 The SEE for Practical work will be conducted jointly by internal and external examiners. However, if external examiner does not turn up, then both the examiners will be internal examiners.

10.4 In case a course is partly P type i.e, (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

10.5 The duration for semester-end practical examination shall be decided by the concerned School Board.

10.5 Evaluation of Minor Project / Major Project / Dissertation:

Right from the initial stage of defining the problem, the candidate has to submit the progress reports periodically and also present his/her progress in the form of seminars in addition to the regular discussion with the supervisor. At the end of the semester, the candidate has to submit final report of the project / dissertation, as the case may be, for final evaluation. The components of evaluation are as follows:

1	First Dissertation presentation describing the problem definition	Should be done a semester before the project semester	Weightage: 0%
2	Dissertation Progress presentation 1	7th week from the start date of project semester	Weightage: 25%
3	Dissertation progress presentation 2	14th Week from the start date of project semester	Weightage -25%
4	Final project Viva and Dissertation Submission	17th -20th Week of project Semester	Weightage: 30% for Dissertation Weightage: 20% for Final Viva Voce

11. Provision for Appeal:

If a candidate is not satisfied with the evaluation of C1, C2 components, he/she can approach the grievance cell with the written submission together with all facts, the assignments, test papers etc, which were evaluated. He/she can do so before the commencement of semester-end examination. The grievance cell is empowered to revise the marks if the case is genuine and is also empowered to levy penalty as prescribed by the university on the candidate if his/her submission is found to be baseless and unduly motivated. This cell may recommend taking disciplinary/corrective action on an evaluator if he/she is found guilty. The decision taken by the grievance cell is final.

For every program there will be one grievance cell. The composition of the grievance cell is as follows:

- The Registrar (Evaluation) - Ex-officio Chairman / Convener.
- One Senior Faculty Member (other than those concerned with the evaluation of the course concerned) drawn from the school / department/discipline and/or from the sister school / department/sister discipline – Member.
- One Senior Faculty Members / Subject Experts drawn from outside the University school / department – Member.

12. **Eligibility to Appear Semester End Examination (SEE):**

12.1. Only those students who fulfil a minimum of 75% attendance in aggregate of all the courses including practical courses / field visits etc, as part of the course(s), as provided in the succeeding sections, shall be eligible to appear for SEE examination.

12.2. Requirements to Pass a Course:

Students are required to score a total minimum of 40% (Continuous Internal assessment and SEE) in each course offered by the University/ Department for a pass (other than online courses) with a minimum of 20 (40% of 50) marks in final examination.

13. Requirements to Pass the Semester:

To pass the semester, a candidate has to secure minimum of 40% marks in each subject / course of the study prescribed in that semester.

13.1 Provision to Carry Forward the Failed Subjects / Courses:

A student who has failed in a given number of courses in odd and even semesters of first year shall move to third semester of second and final year of the study. However, he / she shall have to clear all courses of all semesters within the double duration, i. e., within four years of admission of the first semester failing which the student has to re-register to the entire program.

13.2. Provision to Withdraw Course:

A candidate can withdraw any course within ten days from the date of notification of final results. Whenever a candidate withdraws a course, he/she has to register for the same course in case it is hard core course, the same course or an alternate course if it is Soft Core Course or Open Elective Course.

A DROPPED course is automatically considered as a course withdrawn.

13.3. Re-Registration and Re-Admission:

a) In case a candidate's class attendance in aggregate of all courses in a semester is less than 75% or as stipulated by the University, such a candidate is considered as dropped the semester and is not allowed to appear for end semester examination

(C3) and he / she shall have to seek re-admission to that semester during subsequent semester / year within a stipulated period.

b) In such case where in a candidate drops all the courses in a semester due to personal reasons, it is considered that the candidate has dropped the semester and he / she shall seek re-admission to such dropped semester.

14. Attendance Requirement:

14.1 All students must attend every lecture, tutorial and practical classes.

14.2 In case a student is on approved leave of absence (e g:- representing the university in sports, games or athletics, placement activities, NCC, NSS activities and such others) and / or any other such contingencies like medical emergencies, the attendance requirement shall be minimum of 75% of the classes taught.

a) Any student with less than 75% of attendance in aggregate of all the courses including practical courses / field visits etc, during a semester shall not be permitted to appear to the end semester (C4) examination and such student shall seek re-admission as provided in 7.8.4.

b) Teachers offering the courses will place the above details in the School Board meeting during the last week of the semester, before the commencement of C3, and subsequently a notification pertaining to the above will be brought out by the Director of the School before the commencement of C3 examination. A copy of this notification shall also be sent to the office of the Registrar & Registrar (Evaluation).

15. Absence during Mid Semester Examination:

In case a student has been absent from a mid-semester (C1,C2) examination due to the illness or other contingencies he / she may give a request along with necessary supporting documents and certification from the concerned class teacher / authorized personnel to the concerned Head of the School, for make-up examination. The Head of the School

may consider such request depending on the merit of the case and after consultation with course instructor and class teacher, and arrange to conduct a special test for such candidate(s) well in advance before the C3 examination of that respective semester. Under no circumstances C1, C2 test shall be held after C3 examination.

16. Grade Card and Grade Point:

16.1. **Provisional Grade Card**: The tentative / provisional grade card will be issued by the Registrar (Evaluation) at the end of every semester indicating the courses completed successfully. The provisional grade card provides **Semester Grade Point Average** (SGPA).

16.2. **Final Grade Card:** Upon successful completion of M.Sc., Degree a Final Grade card consisting of grades of all courses successfully completed by the candidate will be issued by the Registrar (Evaluation).

16.3. **The Grade and the Grade Point:** The Grade and the Grade Point earned by the candidate in the subject will be as given below.

Marks P	Grade G	Grade Point (GP=V x G)	Letter Grade
90 >100	10	v*10	O
80 > 90	9	v*9	A+
70 > 80	8	v*8	A
60 > 70	7	v*7	B+
55 > 60	6	v*6	B
50 > 55	5.5	V*5.5	C +
40 > 50	5	v*5	P
0-40	0	v*0	F
ABSENT			AB

O - Outstanding; A-Excellent; B-Very Good; C-Good; D-Fair; E-Satisfactory; F - Fail

Here, P is the percentage of marks (P=[C1+C2]) secured by a candidate in a course which is **rounded to nearest integer**. V is the credit value of course. G is the grade and GP are

the grade point.

16.3.1. Computation of SGPA and CGPA:

The Following procedure to compute the Semester Grade Point Average (SGPA)

The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student in a given semester, i.e:

SGPA (Si) = $\sum$(Ci x Gi) / $\sum$Ci where Ci is the number of credits of the ith course and Gi is the grade point scored by the student in the ith course.

Illustration for Computation of SGPA and CGPA

Illustration No. 1

Course	Credit	Grade Letter	Grade Point	Credit Point (Credit x Grade)
Course 1	4	A+	9	4X9=36
Course 2	4	A	8	4X8=32
Course 3	3	B+	7	3X7=21
Course 4	3	O	10	3X10=30
Course 5	3	P	5	3X5=15
Course 6	3	B	6	3X6=18
Course 7	2	O	10	2X10=20
Course 8	2	A	8	2X8=16
	24			188

Thus, **SGPA = 188 ÷ 24 = 7.83**

Illustration No. 2

Course	Credit	Grade letter	Grade Point	Credit Point (Credit x Grade point)
Course 1	4	A	8	4X8=32
Course 2	4	B+	7	4X7=28
Course 3	3	A+	9	3X9=27
Course 4	3	B+	7	3X7=21
Course 5	3	B	6	3X6=18
Course 6	3	P	5	3X5=15
Course 7	2	B+	7	2X7=21
Course 8	2	O	10	2X10=20
	24			175

Thus, **SGPA = 175 ÷ 24 = 7.29**

Illustration No.3

Course	Credit	Grade Letter	Grade Point	Credit Point (Credit x Grade point)
Course 1	4	O	10	4 x 10 = 40
Course 2	4	A+	9	4 x 9 = 36
Course 3	3	B+	7	3 x 7 = 21
Course 4	3	B	6	3 x 6 = 18
Course 5	3	A+	9	3 x 9 = 27
Course 6	3	B+	7	3 x 7 = 21
Course 7	2	A+	9	2 x 9 = 18
Course 8	2	A+	9	2 x 9 = 18
	24			199

Thus**, SGPA = 199 ÷ 24 = 8.29**

Cumulative Grade Point Average (CGPA):

Overall Cumulative Grade Point Average (CGPA) of a candidate after successful completion of the required number of credits (96) for Two year Post Graduate degree program is calculated taking into account all the courses undergone by a student over all the semesters of a program i. e.,

$CGPA = \sum(Ci \times Si) / \sum Ci$

Where Si is the SGPA of the ith semester and Ci is the total number of credits in that semester.

The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

Illustration: No.1

CGPA after Final Semester

Semester (ith)	No. of Credits (Ci)	SGPA (Si)	Credits x SGPA (Ci X Si)
1	24	6.83	24 x 6.83 = 163.92
2	24	7.71	24 x 7.71 = 185.04
3	24	8.68	24 x 8.68 = 208.32
4	24	9.20	24 x 9.20 = 220.80
Cumulative	96		778.08

Thus, CGPA = $\frac{24x6.83+24x7.13+24x8.68+24x9.20}{96} = 8.11$

16.3.2. CONVERSION OF GRADES INTO PERCENTAGE:

Conversion formula for the conversion of CGPA into Percentage is:

Percentage of marks scored = CGPA Earned x 10

Illustration: CGPA Earned 8.10 x 10=81.0

16.3.3. Classification of Results

The final grade point (FGP) to be awarded to the student is based on CGPA secured by the candidate and is given as follows.

CGPA	Grade (Numerical Index) G	Letter Grade	Performance	FGP Qualitative Index
9 >= CGPA 10	10	O	Outstanding	Distinction
8 >= CGPA < 9	9	A+	Excellent	
7 >= CGPA < 8	8	A	Very Good	First Class
6 >= CGPA < 7	7	B+	Good	
5.5> = CGPA < 6	6	B	Above average	Second Class
> 5 CGPA < 5.5	5.5	C	Average	
> 4 CGPA <5	5	P	Pass	Satisfactory

Overall percentage=10*CGPA

17. Challenge Valuation:

a. A student who desires to apply for challenge valuation shall obtain a photocopy of the answer script by paying the prescribed fee within 10 days after the announcement of the results. He / She can challenge the grade awarded to him/her by surrendering the grade card and by applying along with the prescribed fee to the Registrar (Evaluation) within 10 days after the announcement of the results. This challenge valuation is only for SEE. The answer scripts for which challenge valuation is sought for shall be evaluated by the external examiner who has not involved in the first evaluation. The higher of two marks from first valuation and challenge valuation shall be the final.

b. About any specific case of ambiguity and unsolved problem, the decision of the Vice-Chancellor shall be final.

Attainment of CO (Course Outcome)

CO Attainment	Value
0.4 - 0.6	1
0.6 – 0.75	2
> 0.75	3

Mapping of Course Outcomes with programme Outcomes

Course Code	POS/ COs	PO1	P02	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO 2	PSO 3
M21SN0101	CO1	**3**	**2**	**2**		**3**		**1**	**3**	3	3	3
	CO2	**3**	**3**	**2**		**2**		**1**	**2**	3	3	3
	CO3	**3**	**3**	**2**		**3**		**1**	**1**	3	3	3
	CO4	**3**	**3**	**2**		**2**		**1**	**2**	3	3	3
M21SN0102	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**3**	**1**		**2**	**2**	**1**	**1**	3	3	3
	CO2	**3**	**2**	**1**		**2**	**1**	**2**	**1**	3	3	3
	CO3	**3**	**2**	**1**		**2**	**2**	**2**	**1**	3	3	3
	CO4	**3**	**2**	**1**		**2**	**2**	**2**	**1**	3	3	3
M21SN0103	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**3**	**1**	**2**	**2**	**3**	**2**	**3**	3	3	3
	CO2	**3**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	3	3	3
	CO3	**3**	**2**	**1**		**2**	**2**	**1**	**3**	3	3	3
	CO4	**3**	**2**	**1**	**1**	**2**	**2**	**1**	**3**	3	3	3
M21SN0104	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	2	1	1		1	2	3	3	3
	CO2	3	2	2	1	1		1	2	3	3	3
	CO3	3	2	2	1	1		1	2	3	3	3

	CO4	3	2	2	1			1	3	3	3	3
M21SN0105	**POS/ COS**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**3**	**1**		**2**	**1**	**2**	**2**	3	3	3
	CO2	**3**	**2**	**1**		**1**		**3**	**3**	3	3	3
	CO3	**3**	**2**	**1**		**1**		**3**	**3**	3	3	3
	CO4	**3**	**2**	**1**		**1**		**2**	**2**	3	3	3
M21SNS111	**POS/ Cos**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**3**	**1**	**2**	**2**	**2**	**3**	**3**	3	3	3
	CO2	**3**	**2**	**1**	**2**	**2**	**2**	**3**	**3**	3	3	3
	CO3	**3**	**2**	**1**	**1**	**2**	**1**	**3**	**3**	3	3	3
	CO4	**3**	**2**	**1**		**1**		**2**	**2**	3	3	3
M21SNS112	**POS/ COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	1	1			1		**3**	**3**	**3**
	CO2	3	2	1	1			1		**3**	**3**	**3**
	CO3	3	2	1	1		1		1	**3**	**3**	**3**
	CO4	3	2	2		1		1	2	**3**	**3**	**3**
M21SN0201	**POS/ COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	1	2	1			2	**3**	**3**	**3**
	CO2	3	2	1	2	1		1	1	**3**	**3**	**3**
	CO3	3	2	1	1			1	2	**3**	**3**	**3**
	CO4	3	2	1	2	1		1	3	**3**	**3**	**3**
M21SN0202	**POS/ COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	1		1		1	1	**3**	**3**	**3**
	CO2	3	2	2	1			1	2	**3**	**3**	**3**
	CO3	3	1	2	1	1		1	1	**3**	**3**	**3**
	CO4	3	2	1	1			1	1	**3**	**3**	**3**
M21SN0203	POS/	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO**	**PSO**

	COs										2	3
	CO1	3	2	2	1	1		1	2	**3**	**3**	**3**
	CO2	3	2	2	1	1		1	2	**3**	**3**	**3**
	CO3	3	2	2	1	1		1	2	**3**	**3**	**3**
	CO4	3	2	2	1			1	3	**3**	**3**	**3**
M21SN0204	POS/ COs	PO1	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	2		1	1	1	2	**3**	**3**	**3**
	CO2	3	2	1		1		1	2	**3**	**3**	**3**
	CO3	3	1	2	1	1		1	2	**3**	**3**	**3**
	CO4	3	2	2	1				2	**3**	**3**	**3**
M21SNS211	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**3**	**1**		**1**		**1**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**		**1**		**2**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**		**1**		**2**	**1**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**		**2**		**2**	**3**	**3**	**3**	**3**
M21SNS212	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	1		1		1		**3**	**3**	**3**
	CO2	3	2	2		2		1		**3**	**3**	**3**
	CO3	3	2	2		1		1		**3**	**3**	**3**
	CO4	3	2	2		1		1		**3**	**3**	**3**
M21SNS221	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	1		1			3	**3**	**3**	**3**
	CO2	3	2	1		1			3	**3**	**3**	**3**
	CO3	3	2	2		1			3	**3**	**3**	**3**
	CO4	3	2	1		1			3	**3**	**3**	**3**
M21SNS222	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	3	2	1		1			3	**3**	**3**	**3**
	CO2	3	2	1		1			3	**3**	**3**	**3**

	CO3	3	2	2		1			3	**3**	**3**	**3**
	CO4	3	2	1		1			3	**3**	**3**	**3**
M21SN0301	**POS/ COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**1**	**1**	**2**		**1**		**3**	**3**	**3**
	CO2	**3**	**2**	**2**	**1**	**2**		**1**		**3**	**3**	**3**
	CO3	**3**	**2**	**1**		**1**		**1**		**3**	**3**	**3**
	CO4	**3**	**1**	**2**		**1**		**1**		**3**	**3**	**3**
M21SN0302	**POS/ COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**3**	**2**	**2**		**3**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**3**	**2**	**1**		**2**	**1**	**3**	**3**	**3**
	CO3	**3**	**2**	**3**	**2**	**2**		**3**		**3**	**3**	**3**
	CO4	**3**	**2**	**3**	**2**	**1**		**2**	**1**	**3**	**3**	**3**
M21SNS311	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**2**	**2**			**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**1**	**1**	**2**	**2**		**1**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**	**2**	**1**		**2**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**	**2**	**1**		**1**	**2**	**3**	**3**	**3**
M21SNS312	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**3**	**2**	**2**		**2**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**3**	**2**	**1**		**2**	**2**	**3**	**3**	**3**
	CO3	**3**	**3**	**2**	**2**	**1**		**2**	**1**	**3**	**3**	**3**
	CO4	**3**	**3**	**2**	**2**	**1**		**1**	**2**	**3**	**3**	**3**
M21SNON01	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**2**	**2**			**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**1**	**1**	**2**	**2**		**1**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**	**2**	**1**		**2**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**	**2**	**1**		**1**	**2**	**3**	**3**	**3**

M21SNM301	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**1**		**1**		**2**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**	**1**	**1**		**2**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**	**2**	**1**		**1**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**	**2**	**1**		**2**	**1**	**3**	**3**	**3**
M21SN0401	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**2**	**1**			**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**	**1**	**1**			**1**	**3**	**3**	**3**
	CO3	**3**	**2**	**2**		**2**		**1**	**1**	**3**	**3**	**3**
	CO4	**3**	**1**	**1**	**2**			**1**	**1**	**3**	**3**	**3**
M21SNS411	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**1**	**2**	**1**	**2**		**2**	**2**	**3**	**3**	**3**
	CO2	**3**	**1**	**2**	**2**	**1**		**1**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**2**	**1**	**1**		**2**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**2**	**1**	**1**		**2**	**2**	**3**	**3**	**3**
M21SNS412	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**2**	**2**	**1**	**1**		**1**	**3**	**3**	**3**
	CO2	**3**	**1**	**2**	**1**	**2**	**1**		**1**	**3**	**3**	**3**
	CO3	**3**	**2**	**2**	**1**	**2**		**1**	**1**	**3**	**3**	**3**
	CO4	**3**	**1**	**2**	**1**	**1**		**2**	**1**	**3**	**3**	**3**
M21SN0402	**POS/ COs**	**PO1**	**P02**	**PO3**	**PO4**	**PO5**	**PO6**	**P7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**1**	**2**	**2**	**1**		**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**	**2**	**2**		**2**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**2**	**2**	**2**		**1**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**	**2**	**2**		**1**	**2**	**3**	**3**	**3**
M21SNS421	**POs/ COs**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**2**	**1**	**2**		**1**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**2**	**1**	**1**		**1**	**2**	**3**	**3**	**3**

	CO3	**3**	**2**	**1**	**2**	**1**		**1**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**2**	**1**	**2**		**2**	**2**	**3**	**3**	**3**
M21SNS422	**POS/ COS**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PSO1**	**PSO 2**	**PSO 3**
	CO1	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**			**1**			**3**	**3**	**3**
	CO3	**3**	**2**	**2**	**1**	**2**		**2**	**1**	**3**	**3**	**3**
	CO4	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**3**	**3**	**3**

Mapping of PEO'S with Respect to PO's

	PO1	P2	PO3	PO4	PO5	PO6	P7	PO8
PEO1	√	√	√	√	√	√	√	√
PEO2	√	√	√	√	√	√	√	√
PEO3	√	√	√	√	√	√	√	√

M.Sc. (Mathematics) Program

Scheme of Instruction (effective from Academic Year 2021-23)

Course Code	Course Title	Course Type	Credits				Weekly Contact	Teaching School/Dept.
			L	T	P	Total		
Semester I								
M21SN0101	Algebra	HC	3	1	0	4	5	Mathematics
M21SN0102	Real Analysis	HC	3	1	0	4	5	Mathematics
M21SN0103	Statistical Methods	HC	3	1	0	4	5	Mathematics
M21SN0104	Graph Theory	HC	3	1	0	4	5	Mathematics
M21SN0105	Ordinary and Partial Differential Equations	HC	3	1	0	4	5	Mathematics
M21SNS101	R – Programming with Statistical Methods	SC	1	0	2	3	6	Mathematics
M21SNS102	SAS (Statistical Analysis System)							
	Total Credits of I Semester		16	5	2	23	31	
Semester II								
M21SN0201	Linear Algebra	HC	3	1	0	4	5	Mathematics
M21SN0202	Complex Analysis	HC	3	1	0	4	5	Mathematics
M21SN0203	Data Science	HC	3	1	0	4	5	Mathematics
M21SN0204	Fluid Mechanics	HC	3	1	0	4	5	Mathematics
M21SN0211	Discrete Mathematic	SC	2	1	0	3	4	Mathematics
M21SN0212	Number theory							Mathematics
M21SN0221	Machine Learning using Python	SC	1	1	2	4	6	Mathematics
M21SN0222	SPSS							Mathematics
M21SNM201	Skill Development Programme	MC	2	0	0	2	2	
	Total Credits of II Semester		17	6	2	25	32	
Semester III								
M21SN0301	Topology	HC	3	1	0	4	5	Mathematics
M21SN0302	Functional Analysis	HC	3	1	0	4	5	Mathematics
M21SNS301	Operations Research	SC	2	1	0	3	4	Mathematics
M21SNS302	Mathematical Methods							
M21SN0N01	MOOC / Swayam / Internship	SC	4	0	0	4	4	Mathematics
M21SNM301	Soft Skill Training	MC	2	0	0	2	2	Mathematics
M21SNO301	Open Elective: Optimization Techniques	OE	4	0	0	4	4	Mathematics
M21SNO302	Open Elective: Cryptography							
M21SN0303	Dissertation Phase - I	HC	0	0	2	2	4	Mathematics
	Total Credits of III Semester		18	3	2	23	28	
Semester IV								

M21SN0401		Numerical Analysis					HC	3	1	0	4	5	Mathematics
M21SNS411		Differential Geometry					SC	2	1	0	3	4	Mathematics
M21SNS412		Finite Element Methods											
M21SN0402		Calculus of Variation and Integral Equations					HC	3	1	0	4	5	Mathematics
M21SNS421		Fuzzy set theory and Applications					SC	2	1	0	3	4	Mathematics
M21SNS422		Advanced Graph Theory											
M21SN0403		Dissertation Phase - II					HC	0	0	4	5	8	Mathematics
		Total Credits of IV Semester						10	4	4	19	26	
HC	SC	OE	RUL	I Sem	II Sem	III Sem	IV Sem	L	T	P	Total	Total	
59	19	04	08	23	25	23	19	61	18	10	90	117	

Note:

1. Open Elective offered by School of Mathematics, shall be opted by other schools.

2. The M.Sc. (Mathematics) students shall have to opt Open Elective.

3. Project dissertation will begin in 4thSemester. Students will be chosen internal guide from the school and continue with in-house projects only.

4. Internship – Students must undergo hands-on training program (Skill development program) either at REVA University/Industry/Research Organization.

Semester-wise Summary of Credit Distribution

Semester	L	T	P	No. of Credits	No. of Hours	HC	SC	OE	RULO	Total
I	16	05	02	23	31	20	03	00	00	23
II	17	06	02	25	32	16	07	00	02	25
III	18	3	2	23	28	10	03	04	06	23
IV	10	4	4	19	26	13	6	00	00	19
Total Credits	66	20	10	90	117	59	19	04	08	90

HC = Hard Core; SC = Soft Core; OE = Open Elective; MC= Mandatory Course

M.Sc. (Mathematics) Program

Detailed Syllabus

(Effective from Academic Year 2020-21)

SEMESTER - I

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0101	ALGEBRA	HC	3	1	0	4	5

Course Objectives:

The overall objectives of the course are:

1. Student will gain an understanding of the Cayley's theorem, Sylow's theorem and finite abelian group.
2. Student will study the ring and field over polynomials.
3. Student will read and analyse Galois theory.
4. Student will read and analyse the linear transformation, unitary and normal transformation.

Course Outcomes:

After completing the course, the student should be able to:

1. Analyze the concept of various groups and theorems.
2. Analyze the concept of polynomial rings, polynomial rings over rational field, commutative ring and construct with straightedge and compass.
3. Analyze Galois Theory, Galois group over the rational and finite fields.
4. Apply the concept of linear transformation, canonical forms, and real quadratics forms.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	2		3		1	3			
	CO2	3	3	2		2		1	2			
	CO3	3	3	2		3		1	1			
	CO4	3	3	2		2		1	2			

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

Unit I: 15 hrs

Automorphisms, Cayley's theorem, Cauchy's theorem, permutation groups, symmetric groups, alternating groups, simple groups, conjugate elements, and class equations of finite groups, Sylow's theorems, direct products, finite abelian groups, solvable groups

UNIT-II: 15 hrs

Polynomial rings, polynomials rings over the rational field, polynomial rings over commutative rings, extension fields, roots of polynomials, construction with straightedge and compass, more about roots

UNIT-III: 15 hrs

Galois Theory: The elements of Galois theory, solvability by radicals, Galois group over the rationals, finite fields

UNIT-IV: 15 hrs

Algebra of linear transformations, characteristic roots, canonical forms - triangular, nilpotent and Jordan forms, Hermitian, unitary, and normal transformations, real quadratic forms.

Reference Books:

1. M. Artin, Algebra, Prentice Hall of India, 1994.
2. D. S. Dummit and R. M. Foote, Abstract Algebra, 2nd Edition, John Wiley, 2002.
3. J. A. Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa, 1999.
4. N. Jacobson, Basic Algebra I, 2nd Edition, Hindustan Publishing Co., 1984, W. H. Freeman, 1985.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0102	REAL ANALYSIS	HC	3	1	0	4	5

Course Objectives:

1. Student will gain an understanding of the Metric space, the limit and continuous function.
2. Student will read and analyse the Riemann - Stieltjes integrals.
3. Student will read and analyse the sequence and series of functions.
4. Student will study the Lebesgue integration on measurable functions and Function of several variables.

Course out comes: After completing the course, the student should be able to

1. Analyse the concept of Metric space, continuity, compactness of continuity and monotone function.
2. Apply the Riemann-Stieltjes integrals for various differentiation and integration problems.

3. Apply the concept of Uniform convergence and continuity in differentiation, integration, and polynomial.

4. Analyze the concept of Lebesgue measurable theory for sets and functions also, the function of several variables.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**3**	**1**		**2**	**2**	**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**		**2**	**1**	**2**	**1**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**		**2**	**2**	**2**	**1**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**		**2**	**2**	**2**	**1**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**15**
CO2	**7.5**		**5**	**12.5**	**25**	**15**
CO3		**7.5**	**5**	**12.5**	**25**	**15**
CO4		**7.5**	**5**	**12.5**	**25**	**15**
Total	**15**	**15**	**20**	**50**	**100**	**60**

Course Content: **Total Hours: 60 hrs**

Unit-1: 15 hrs

Introduction, metric spaces-connectedness, compact sets, Bolzano Weierstrass theorem, Heine - Borel theorem, Perfect sets, Connected sets. Limits of functions- Continuous functions- Continuity and compactness, Continuity and connectedness- Discontinuities – Monotone function and functions of bounded variation.

Unit - 2: 15 hrs

Riemann-Stieltjes integral; definition and existence of the integral, linear properties, change of variables, integral as a limit of sum. Integration and differentiation, integration of vector valued

functions, Rectifiable curves. Monotonic functions, types of discontinuity, functions of bounded variation.

Unit-3: 15 hrs

Sequences and series of functions: Uniform convergence- Uniform convergence and continuity- Uniform convergence and integration- Uniform convergence and differentiation- Approximation of a continuous function by a sequence of polynomials.

Unit: 4 15 hrs

Function of several variable: Linear Transformations, Differentiation, The Contraction Principle, The Inverse Function theorem, The Implicit Function Theorem, The Rank theorem, Lebesgue measure, measurable functions; Lebesgue integral, Fatou's lemma, monotone convergence theorem, dominated convergence theorem.

Reference Books

1. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition. McGraw Hill Company, New York, 1976.
2. T. M. Apostol: Mathematical Analysis, New Delhi, Narosa, 2004.
3. Bartle, R. G./Donald R. Sherbert. Introduction to Real Analysis, John Wiley and Sons Inc., 4th edition 2017.
4. Malik S. C. and Savita Arora. Mathematical Anslysis, Wiley Eastern Limited.New Delhi, 1991.
5. Sanjay Arora and Bansi Lal, Introduction to Real Analysis, Satya Prakashan, New Delhi, 1991.
6. A. L. Gupta and N. R. Gupta, Principles of Real Analysis, Pearson Education, (Indian print) 2003.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0103	STATISTICAL METHODS	HC	3	1	0	4	5

Course Objective: The overall objectives of the course are:

1. Analyze the data numerically and graphically.
2. Apply the measures of location and measure of dispersion for grouped and ungrouped data cases.
3. Analyze the classical optimization techniques and numerical methods of optimization.
4. Apply the concepts of probability models to the real-world problems.

Course Outcomes: After completing the course, the student should be able to:

1. Produce graphical representations of data.
2. Compute the different measures of central tendency and dispersion and its various measures.
3. Form the optimization problem and apply various optimization technique to solve real world problems.
4. Apply various methods of non-linear programming to compute engineering problems.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**3**	**1**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**		**2**	**2**	**1**	**3**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**	**1**	**2**	**2**	**1**	**3**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

UNIT I: 15 hrs

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.

UNIT II: 15 hrs

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections.

Unit III: 15 hrs

Simple correlation and regression: Bivariate data, meaning of correlation, Types of correlation, correlation coefficient, scatter diagram method, karl-Pearson's and Spearman's correlation coefficients their properties. Simple regression lines, properties of regression coefficients

Unit IV: 15 hrs

Probability as a set function, continuity axiom of probability, Borel - Cantelli lemma, random variable, distribution function and its properties, discrete and continuous distribution functions, convolutions of random variables, vector of random variables and statistical independence. Notion of mathematical expectation, conditional expectation, moment inequalities – Markov, Chebyshev, Kolmogorov, Holder, minkowski. Characteristic function – Inversion theorem.

Reference Books:

1. Dudewicz E. J and Mishra S. N. (1988): Modern Mathematical Statistics, Wiley, International Students Edition.
2. Rohatgi V. K. (1984): An Introduction to probability theory and mathematical statistics.
3. Rao C. R. (1973): Linear Statistical Inference and its Applications, 2/e, Wiley Eastern.
4. Pitman J. (1993): Probability, Narosa Publishing House.
5. S. C. Gupta and V. K. Kapoor: Fundamentals of Mathematical Statistics. Sulthan and Chand Company.
6. Mukhopadhyay P. (2002), Mathematical Statistics, Books and Allied (p) Ltd., Kolkata.
7.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0104	GRAPH THEORY	HC	3	1	0	4	5

Course Objectives: **The overall objectives of the course are:**

1. This course is aimed to demonstrate variety of problems in Graph Theory.
2. In this course student will Interpret Theorems in real life scenario.
3. This course is aimed to interpret various techniques to find shortest distance in a network.
4. This course will demonstrate the graphs algorithms.

Course Outcomes: After completing the course, the student should be able to:

1. Apply the concept of connectivity and analyse real time applications, utility problems, mapping problems.
2. Apply the concept of planarity and analyse 2D circuit problem (minimizing the number of intersection of wires).

3. Apply the concept of colorability and analyse mobile frequency distributions.
4. Apply the concept of matching to estimate the bond lengths and analyse the concept of matching to solve TSP.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	2	1	1		1	2	**3**	**3**	**3**
	CO2	3	2	2	1	1		1	2	**3**	**3**	**3**
	CO3	3	2	2	1	1		1	2	**3**	**3**	**3**
	CO4	3	2	2	1			1	3	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**15**
CO2	**7.5**		**5**	**12.5**	**25**	**15**
CO3		**7.5**	**5**	**12.5**	**25**	**15**
CO4		**7.5**	**5**	**12.5**	**25**	**15**
Total	**15**	**15**	**20**	**50**	**100**	**60**

Course Content: **Total Hours: 52 hrs**

Unit 1: 15 hrs

Definition and introductory concept, Graphs as Models, Isomorphism, Decomposition and special graphs, Bipartite Graphs, Operation on graphs, Connected and Disconnected graphs, Weakly Connected and Strongly Connected Graphs, Components, Complement of graph, Partition, Decomposition Eulerian Graphs, Hamilton Graphs, Directed graphs.

Unit 2: 15 hrs

Planar graphs, Dual of the Planar Graphs, Euler's Formula, Kuratowskis's Theorem. matching, maximum matchings, Hall's Matching Condition, Hall's theorem, Network flow and its applicationsCut set, Cut vertex, Chord, Properties of Cut set, Max flow Min cut theorem.

Definition and Examples of Graph coloring, Chromatic number, Chromatic Polynomial of a Graphs, Four Color Problem, Five Color Theorem

Unit 3: 15 hrs

Properties of Trees, Distance in Trees and Graphs, Enumeration of Trees, Spanning Trees in Graphs, Decomposition and Graceful Labeling, Minimum Spanning Tree, Shortest Paths, Minimal Spanning tree algorithm, Sorting, Depth-First Search (DFS), Breadth-First Search(BFS), Prefix codes, Weighted trees, Matrix representation, Incidence matrix, Circuit matrix, Fundamental circuit matrix, Cut set matrix, Adjacency matrix, Path matrix.

Unit 4: 15 hrs

Introduction, Algorithm efficiency, In order and Post order Algorithms, Minimal spanning tree algorithm-Kruskal algorithm, Prim's algorithm, Shortest path algorithm- Dijikstra's algorithm, Warshall- Floyd's algorithm, Algorithm for connectedness and components, Travelling Salesman problem(TSP), Algorithm for TSP (to find Hamilton Circuit).

REFERENCE BOOKS:

1. F. Harary: Graph Theory, Addison -Wesley,1969.
2. G. Chartrand and Ping Zhang: Introduction to Graph Theory. McGrawHill, International edition (2005).
3. J. A. Bondy and V. S. R. Murthy: Graph Theory with Applications, Macmillan, London, (2004).
4. D. B. West, Introduction to Graph Theory, Pearson Education Asia, 2nd Edition, 2002.
5. Charatrand and L. Lesnaik-Foster: Graph and Digraphs, CRC Press (Third Edition), 2010.
6. T. W. Haynes, S. T. Hedetneime and P. J. Slater: Fundamental of domination in graphs, Marcel Dekker. Inc. New York.1998.
7. J. Gross and J. Yellen: Graph Theory and its application, CRC Press LLC, Boca Raton, Florida, 2000.
8. N. Deo: Graph Theory: Prentice Hall of India Pvt. Ltd. New Delhi – 1990.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0105	ORDINARY AND PARTIAL DIFFERENTIAL	HC	3	1	0	4	5

Course Objective: The overall objectives of the course are:

1. Identify essential characteristics of ordinary differential equations.
2. To develop strong background on finding solutions to linear second and higher order differential equations with constant and variable coefficients.
3. Partial differential equations allow deterministic mathematical formulations of phenomena in physics and engineering as well as biological processes.
4. This course is to present the main results in the context of partial differential equations that allow learning about these models and to study numerical methods for the approximation of their solution.

Course outcome: After completing the course, the student should be able to:

1. Compute the Wronskian using variation of parameter method.
2. Analyze different types of differential equations using power series method.
3. Apply first order and second order partial differential equations by reducing in to canonical form.
4. Solve the PDE by variable separable method.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**3**	**1**		**2**	**1**	**2**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**		**1**		**3**	**3**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**		**1**		**3**	**3**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**		**1**		**2**	**2**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

Unit-1: 15 hrs

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. Wronskian - Abel's identity, theorems on linear dependence of solutions. The nth order non-homogeneous linear equations - Variation of parameter method, zeros of solutions - comparison and separation theorems.

Unit-2: 15 hrs

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. General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

Unit 3: 15 hrs

First Order Partial Differential Equations- Cauchy problem, the method of characteristics for Semi linear, quasi linear and Non-linear equations. Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs Classification of second-order linear partial differential equations into hyperbolic, parabolic, and elliptic PDEs, Reduction to canonical forms.

Unit 4: 15 hrs

Homogeneous and non-homogeneous PDE with constant coefficients, second order PDE with variable coefficients, Heat equation, Wave equation: Solution by the method of separation of variables. Laplace equation: Solution by the method of separation of variables.

Reference books:

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, New York, 1984.
4. I. N. Sneddon, Elements of PDE's, McGraw Hill Book company Inc., 2006.
5. F. John, Partial differential equations, Springer, 1971.
6. E. D. Rainville and P. E. Bedient: Elementary Differential Equations, McGraw Hill, NewYork,1969.
7. E. A. Coddington and N. Levinson: Theory of ordinary differential equations, McGraw Hill,1955.
8. A. C. King, J. Billingham & S.R. Otto: Differential equations, Cambridge University Press, 2006.
9. M. G. Smith: Introduction to the theory of partial differential equations, Van Nostrand, 1967.
10. Shankar Rao: Partial Differential Equations, PHI, 2006.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS101	R-PROGRAMMING WITH STATISTICS	SC	1	0	2	3	6

Course Objective: The overall objectives of the course are:

1. To introduce the basic concepts and techniques of R-Programming
2. Introduce the statistical foundations required for R-Programming
3. To introduce participants to know the fundamentals of R-Programming
4. To gain experience of doing independent study and research.

Course Outcome: After completing the course, the student should be able to:

1. Develop a R-script with available data types and operators.
2. Apply decision and repetition structures in R-script.
3. Develop simple programs in R for mathematical problems.
4. Apply the regression coefficients by using R.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	3	1	2	2	2	3	3	3	3	3
	CO2	3	2	1	2	2	2	3	3	3	3	3
	CO3	3	2	1	1	2	1	3	3	3	3	3
	CO4	3	2	1		1		2	2	3	3	3

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	18
CO2	7.5		5	12.5	25	18
CO3		7.5	5	12.5	25	18
CO4		7.5	5	12.5	25	18
Total	15	15	20	50	100	72

Course Content: **Total Hours: 52 hrs**

Introduction to R-Programming:

Prerequisite: Students should have a basic understanding of Computer Programming terminologies. A basic understanding of any of the programming languages will help you in understanding the R programming concepts and move fast on the learning track.

Fundamentals in R: basic syntax : R command prompt , script file ,comments, data types : lists ,matrices , arrays, factors ,data frames , variables: variable assignment ,data type of a variable, finding variables ,deleting variables, operators: types of operators ,arithmetic operators ,

relational operators, logical operators , assignment operators, miscellaneous operators , decision making : if statement ,if...else statement ,the if...else if...else statement ,switch statement, Loops, Functions, R-graphical representation of Data, R-measure of central tendency, R-regression ,R-distributions (Binomial and Normal).

R List of Experiments:

1. Write an R script to demonstrate use of variables.
2. Write an R script to demonstrate use of vector and matrix data types.
3. Write an R script to demonstrate use of Data frames.
2. Write an R script to demonstrate use of Lists.
3. Write an R script to demonstrate use of conditional statements if, if-else.
4. Write an R script to demonstrate use of arithmetic, logical operators.
5. Write an R script to demonstrate use of loops.
6. Write an R script to demonstrate use of functions.
7. Write an R script to demonstrate use of visualizations in R - basic plot, g plot.
8. Write an R script to demonstrate use of 3d visualization in R-scatterplot3d.
9. Write an R script to demonstrate use of probability library - prob to find probability of coin toss.
10. Write an R script to demonstrate use of set operations.
11. Write an R script to demonstrate use of conditional probability.
12. Write an R script to demonstrate use of covariance on a data set.
13. Write an R script to demonstrate use of correlation on a data set.
14. Write an R script to demonstrate use of linear regression.
15. Write an R script to demonstrate use of multiple regression.
16. Write an R script to demonstrate use of logistic regression.
17. Write an R script to demonstrate use of normal distribution.
18. Write an R script to demonstrate use of binomial distribution.

Books for References:

1. The R Book by Michael R Crawley, John Wiley & Sons Ltd.
2. The Art of R-Programming by Norman Matloff.
3. R cook book by Paul Teetor, Oreilly Ltd.
4. Introduction to Probability and Statistics Using R, G. Jay Kerns, First Edition.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS102	STATISTICAL ANALYSIS USING SPSS	SC	1	0	2	3	6

Course Objective: The overall objectives of the course are:

1 To train students in SPSS Software

2 To expose the students to the analysis of statistical data

Course Outcome: After completing the course, the student should be able to:

1. Develop a SPSS with available data types and operators.
2. Apply decision and repetition structures in SPSS.
3. Develop simple programs in SPSS for mathematical problems.
4. Apply the regression coefficients by SPSS.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**3**	**1**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**	**1**	**2**	**1**	**3**	**3**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**		**1**		**2**	**2**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	18
CO2	7.5		5	12.5	25	18
CO3		7.5	5	12.5	25	18
CO4		7.5	5	12.5	25	18
Total	15	15	20	50	100	72

Course Content: **Total Hours: 72 hrs**

Unit I: 18 hrs

Data handling: open SPSS data file – save – import from other data source – data entry – labelling for dummy numbers - recode in to same variable – recode in to different variable – transpose of data – insert variables and cases – merge variables and cases.

Unit II: 18 hrs

Data handling: Split – select cases – compute total scores – table looks – Changing column - font style and sizes

Unit III: 18 hrs

Descriptive Statistics - Mean, Median, Mode, SD- Skewness- Kurtosis. Correlation – Karl Pearson's and Spearman's Rank Correlation,

Unit IV: 18 hrs

Regression analysis: Simple and Multiple Regression Analysis

List of Practicals:

1. Formation of discrete and continuous frequency distributions - descriptive statistics.
2. Graphs and diagrams: Pie, bar, line and scatter diagrams- Histogram and Normal probability plot
3. Correlation coefficient rank correlation, partial and multiple correlations.
4. Regression: Simple and multiple linear regression.
5. Curve estimation.
6. Compare means: Independent sample test and paired t- test.
7. Cross tabulation and Chi-square – test.
8. One way and two way ANOVA – Factorial designs.

9. Non parametric test: Binomial tests, run test, sign test, Median test, Mann-Whitney test, Kruskal-Wallis, Kendall's and Friedman tests.

Reference Books:

1. Clifford E. Lunneborg (2000). Data analysis by resampling: concepts and applications. Dusbury Thomson learning. Australia.
2. Everitt B. S. and Dunn G. (2001). Applied multivariate data analysis. Arnold London.
3. Books for reference:
4. Jeremy J. Foster (2001). Data analysis using SPSS for windows. New edition. Versions 8-10. Sage publications. London.
5. Michael S. Louis – Beck (1995). Data analysis an introduction, Series: quantitative applications in the social sciences. Sage. Publications. London.

II SEMESTER

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0201	LINEAR ALGEBRA	HC	3	1	0	4	5

Course Objectives: The overall objectives of the course are:

1. Present methods of solving systems of linear equations.
2. Demonstrate basic concepts of vector spaces.
3. Interpret the concepts of linear transformations by using the matrices.
4. Develop methods of computing and using eigen values and eigenvectors.

Course Outcomes: **After completing the course, the student should be able to:**

1. Analyse the system of Linear Equations by using Matrix Algebra.
2. Apply the Norms and Inner Product Spaces.
3. Comprehend the vector space properties.
4. Analyse different forms of the Linear Transformations.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	1	2	1			2	**3**	**3**	**3**
	CO2	3	2	1	2	1		1	1	**3**	**3**	**3**
	CO3	3	2	1	1			1	2	**3**	**3**	**3**
	CO4	3	2	1	2	1		1	3	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

Unit I: 15 hrs

Vector Spaces, Subspaces, Linear Combinations and Systems of Linear Equations, Linear Dependence and Linear Independence, Bases and Dimension, Maximal Linearly Independent Subsets; Linear Transformations, Null Spaces, and Ranges, The Matrix Representation of a Linear Transformation, Composition of Linear Transformations, and Matrix Multiplication, Invertibility and Isomorphisms, The Change of Coordinate Matrix, The Dual Space; Elementary Matrix Operations and Elementary Matrices, The Rank of a Matrix and Matrix Inverses, Systems of Linear Equations.

Unit II: 15 hrs

Properties of Determinants, Cofactor Expansions, Elementary Operations and Cramer's Rule; Eigenvalues and Eigenvectors, Diagonalizability, Invariant Subspaces and the Cayley-Hamilton Theorem; Inner Products and Norms, The Gram-Schmidt Orthogonalizing Process and Orthogonal Complements.

Unit III: 15 hrs

The Adjoint of a Linear Operator, Normal and Self-Adjoint Operators, Unitary and Orthogonal Operators and Their Matrices, Orthogonal Projections and the Spectral Theorem; Bilinear and Quadratic Forms.

Unit IV: 15 hrs

The Diagonal form, The Triangular form; The Jordan Canonical Form; The Minimal Polynomial; The Rational Canonical Form.

Books for Reference:

1. S. Friedberg, A. Insel, and L. Spence - Linear Algebra, Fourth Edition, PHI, 2009.
2. Jimmie Gilbert and Linda Gilbert – Linear Algebra and Matrix Theory, Academic Press, An imprint of Elsevier.
3. I. N. Herstein – Topics in Algebra, Vikas Publishing House, New Delhi.
4. Hoffman and Kunze – Linear Algebra, Prentice-Hall of India, 1978, 2nd Ed.
5. P. R. Halmos – Finite Dimensional Vector Space, D. Van Nostrand, 1958.
6. S. Kumeresan – Linear Algebra, A Geometric approach, Prentice Hall India, 2000.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0202	COMPLEX ANALYSIS	HC	3	1	0	4	5

Objectives: The overall objectives of the course are:

1. Students will study the analytic function and Cauchy's theorem for triangular, rectangular, circular regions also Liouliies theorem.
2. Students will study Power series.
3. Student will read and analyse the singularities.
4. Student will read and analyse the Residues theorem, and Contour integrals.

Course Outcome: After completing the course, the student should be able to:

1. Analyse the limit and continuity for function of complex variable.
2. Formulate Complex Contour integrals by applying the Cauchy's integral theorem in its various versions.
3. Analyse sequences and series of analytic functions and types of convergence.
4. Apply residue theorem to evaluate complex integrals and interpret results.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	1		1		1	1	**3**	**3**	**3**
	CO2	3	2	2	1			1	2	**3**	**3**	**3**
	CO3	3	1	2	1	1		1	1	**3**	**3**	**3**
	CO4	3	2	1	1			1	1	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**15**
CO2	**7.5**		**5**	**12.5**	**25**	**15**
CO3		**7.5**	**5**	**12.5**	**25**	**15**
CO4		**7.5**	**5**	**12.5**	**25**	**15**
Total	**15**	**15**	**20**	**50**	**100**	**60**

Course Content: **Total Hours: 60 hrs**

Unit I: 15 hrs

Analytic functions, Mobius Transformation, Conformal mappings, Cauchy's Theorem and Integral formula, Morera's Theorem, Cauchy's Theorem for triangle, rectangle, Cauchy's Theorem in a disk, Liouville's Theorem.

Unit II: 15 hrs

Maximum modulus Principle, Hadmard's Three circle theorem, Schwartz lemma, Open mapping theorem. Zeros of an analytic function, Fundaments theorem of algebra. Series, Uniform convergence, Power series, Radius of convergences, Taylor's series, Laurent's series.

Unit III: 15 hrs

Classification of Singularities: Singularities, Poles, Classification of Singularities, Characterization of removable Singularities, poles. Behavior of an Analytic functions at an essential singular point. Entire and Meromorphic functions. The Residue Theorem, Evaluation of simple integrals using Residues theorem, Rouche's theorem and problems.

Unit IV: 15 hrs

Contour Integration: Integrals Type $\int_{\infty}^{2\pi+\infty} R(\cos\theta,\sin\theta)\,d\theta$, Integrals Type $\int_{-\infty}^{\infty} f(x)dx$ Integrals Type $\int_{-\infty}^{\infty} f(x)\cos mxdx$ (or) $\int_{-\infty}^{\infty} f(x)\sin mxdx$, Analytic Continuation: Direct Analytic Continuation, Monodromy Theorem, Poisson Integral formula, Infinite Sums and Meromorphic Function, Infinite Product of Analytic function.

Reference Books:

1. S. Ponnaswamy : Functions of Complex variable, Narosa Publications-1997.
2. J. B. Conway : Functions of one complex variable, Narosa, 1987.
3. L. V. Ahlfors : Complex Analysis, McGraw Hill, 1986.
4. R. Nevanlinna :Analystic functions, Springer, 1970.
5. E. Hille : Analytic Teory, Vol. I, Ginn, 1959.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0203	DATA SCIENCE	HC	3	1	0	4	5

Course Objectives: The overall objectives of the course are:

1. Provide insights about the basic roles of a Data Scientist. Develop a greater understanding of the importance of Data Visualization techniques.
2. Develop problem-solving skills.
3. Make inferences about the population parameters using sample data.
4. Test a hypothesis about the population parameters to draw meaningful conclusions.

5. Provide an understanding on the importance and techniques of predicting a relationship between the two sets of data and determine the goodness of fit model.

Course Outcomes: After completing the course, the student should be able to:

1. Develop various visualizations of the data in hand and communicate results of analysis effectively (visually and verbally).
2. Analyze a real-word problem and solve the same with the knowledge gained from various distributions study.
3. Develop and test a hypothesis about the population parameters to draw meaningful conclusions.
4. Fit a regression model to data and use it for prediction.

Mapping of Course Outcomes with Program Outcome:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	2		1	1	1	2	**3**	**3**	**3**
	CO2	3	2	1		1		1	2	**3**	**3**	**3**
	CO3	3	1	2	1	1		1	2	**3**	**3**	**3**
	CO4	3	2	2	1				2	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**15**
CO2	**7.5**		**5**	**12.5**	**25**	**15**
CO3		**7.5**	**5**	**12.5**	**25**	**15**
CO4		**7.5**	**5**	**12.5**	**25**	**15**
Total	**15**	**15**	**20**	**50**	**100**	**60**

Course Content: **Total Hours: 60 hrs**

Unit – I: 15 hrs

Introduction to Data Science: Introduction, Sampling Methods and Sampling Errors. Getting and Analyzing Data: Reading Files, Scraping the Web, Need for Data Cleaning and its Basics.

Statistics: Introduction, Types of Statistics. Data Visualization and Interpretation: Histogram, Bar Charts, Box Plots, Scatter Plots, Heat Maps, Good vs. Bad Visualization, Case Study.

Random Variables: Random Variables, Expectation, Functions of Random Variables. Probability Distributions: Discrete Distributions (Bernoulli, Binomial, Poisson), Continuous Distributions (Normal), Derivation of Distributions, Case Study.

Unit – II: 15 hrs

Probability Distributions: Principles of Point Estimation – Mean Square Error, Maximum Likelihood Estimate, The Central Limit Theorem and Applications, Normal Probability Plots. Confidence Intervals: Using Simulation to Construct Confidence Intervals. Interval Estimates for Mean of Large and Small Samples, Interval Estimates for proportion of Large Samples. Confidence Intervals for the difference between Two Means, Interval Estimates for Paired Data. Factors affecting Margin of Error, Case Study

UNIT- III: 15 hrs

Hypothesis and Inference: Hypothesis Testing for Population Mean and Population Proportion of Large Samples, Drawing conclusions from the results of Hypothesis tests, Large sample tests for a Population proportion, Large – Sample tests for Difference between two means, Distribution Free Tests, Chi-squared Test, Fixed Level Testing, Type 1 and Type 2 Errors, Case Study.

UNIT-IV: 15 hrs

Power of Test and Simple Linear Regression: Power of a Test, Factors Affecting Power of a Test. Simple Linear Regression: Introduction, Correlation, the Least Square Lines, Predictions using regression models – Uncertainties in Regression Coefficients, Checking Assumptions and transforming data, Case Study.

Reference Books:

1. "Statistics for Engineers and Scientists", William Navidi, McGraw Hill Education, India, 4th Edition, 2015.
2. Raj Jain, "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation , and Modeling", Wiley, 2008.
3. Sharon L. Lohr ,"Sampling – Design and Analysis", 2nd edition (stats), Cengage,2010
4. "Data Science from Scratch", Joel Grus, o'Reilly, 1st Edition,2015.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0204	FLUID MECHANICS	HC	3	1	0	4	5

Course Objective: **The overall objectives of the course are:**

1. This course aims at studying the fundamentals of fluid mechanics such as tensors, kinematics of fluid, incompressible flow, and boundary layer flows.
2. This course aims at study of fluid flows such as viscous flow, inviscid flow, incompressible flow, and boundary layer flows.

Course outcome: After completing the course, the student should be able to:

1. Apply the concepts of tensors in continuum hypothesis, material and spatial coordinates
2. Analyse the laws of conservations.
3. Analyse the dimensional and non-dimensional parameters.
4. Analyse the different types of fluid flow problems.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	1		1		1		**3**	**3**	**3**
	CO2	3	2	2		2		1		**3**	**3**	**3**
	CO3	3	2	2		1		1		**3**	**3**	**3**
	CO4	3	2	2		1		1		**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

Unit I: 15hrs

Coordinate transformations - Cartesian tensors - Basic Properties - Transpose - Symmetric and Skew tensors - Isotropic tensors- Deviatoric Tensors - Gradient, Divergence and Curl in Tensor Calculus - Integral Theorems. Continuum Hypothesis- Configuration of a continuum – Mass and density – Description of motion – Material and spatial coordinates - Translation – Rotation - Deformation of a surface element-Deformation of a volume element - Isochoric deformation – Examples - Stretch and Rotation- Decomposition of a deformation- Deformation gradient - Strain tensors - Infinitesimal strain - Compatibility relations - Principal strains.

Unit II: 15hrs

Material and Local time derivatives. - Strain-rate tensor- Transport formulas – Stream lines - Path lines - Vorticity and Circulation - Examples. Stress components and Stress tensor - Normal and shear stresses - Principal stresses. Fundamental basic physical laws- Law of conservation of mass - Principle of linear and momentum - Balance of energy - Examples. Equations of fluid mechanics – Viscous and non-viscous fluids –Stress tensor for a viscous fluid – Navier-Stokes equation - simple consequences and simple applications.

Unit III: 15hrs

Motion of inviscid fluids:- Recapitulation of equation of motion and standard results - Vortex motion-Helmholtz vorticity equation - Permanence of vorticity and circulation - Kelvin’s minimum energy theorem – Impulsive motion - Dimensional analysis - Nondimensional numbers. Two dimensional flows of inviscid fluids:- Meaning of two-dimensional flow - Stream function – Complex potential - Line sources and sinks - Line doublets and vortices - Images - Milne-Thomson circle theorem and applications - Blasius theorem and applications.

Unit IV: 15 hrs

Motion of Viscous fluids:- Stress tensor – Navier-Stokes equation - Energy equation - Simple exact solutions of Navier-Stokes equation: (i) Plane Poiseuille and Hagen- Poiseuille flows (ii) Generalized plane Couette flow (iii) Steady flow between two rotating concentric circular cylinders (iv) Stokes's first and second problems. Diffusion of vorticity - Energy dissipation due to viscosity.

Reference Books:

1. D. S. Chandrasekharaiah and L. Debnath: Continuum Mechanics, Academic Press, 1994.
2. A. J. M. Spencer: Continuum Mechanics, Longman, 1980.
3. S. W. Yuan : Foundations of Fluid Mechanics, Prentice Hall, 1976.
4. P. Chadwick : Continuum Mechanics, Allen and Unwin, 1976.
5. L. E. Malvern : Introduction to the Mechanics of a Continuous Media, Prentice Hall,1969.
6. Y. C. Fung, A First course in Continuum Mechanics, Prentice Hall (2nd edition), 1977.
7. Pijush K. Kundu, Ira M. Cohen and David R. Dowling, Fluid Mechanics, Fifth Edition, 2010.
8. C. S. Yih : Fluid Mechanics, McGraw-Hill, 1969.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS211	DISCRETE MATHEMATICS	SC	2	1	0	3	4

Course Objectives: The overall objectives of the course are:

1. Recall basic Techniques in Counting
2. Demonstrate basic logic.
3. Interpret the combinatorial ideas in practical problems.
4. Develop the basics in Coding theory.

Course Outcomes: After completing the course, the student should be able to:

1. Distinguish the Tautologies and Contradictions.
2. Annalise the ideas of permutations and combinations.
3. Develop the ideas of Groups and Rings in Coding Theory.
4. Apply the ideas of Possets and Lattices in Boolean Algebra.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**3**	**1**		**1**		**1**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**		**1**		**2**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**		**1**		**2**	**1**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**		**2**		**2**	**3**	**3**	**3**	**3**
	CO4	3	2	2		1		1	2	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**12**
CO2	**7.5**		**5**	**12.5**	**25**	**12**
CO3		**7.5**	**5**	**12.5**	**25**	**12**
CO4		**7.5**	**5**	**12.5**	**25**	**12**
Total	**15**	**15**	**20**	**50**	**100**	**48**

Course Content: **Total Hours: 48 hrs**

Unit I: 12 hrs

Sets: Definition of sets, subsets, standard set operations; union, intersection, relative complement, symmetric difference, complement, Cartesian products, power sets; algebraic laws; cardinality of finite sets. Propositional logic, first order logic, Basic logical operation, Tautologies, contradictions, Logical equivalences, Predicates, Universal and existential quantifiers, Rules of inferences.

Unit II: 12 hrs

Permutations and Combinations, Multinomial theorem, Circular Permutations, Solutions in Non-negative Integers, Set Partitions, Catalan Numbers, Advanced Counting Principles, Pigeonhole Principle, Principle of Inclusion and Exclusion.

Unit III: 12 hrs

Definitions, Examples, and Elementary Properties: Groups, Homomorphisms, Isomorphisms, and Cyclic Groups,Rings Coding Theory: Elements of Coding Theory, The Hamming Metric, The Parity Check, and Generator Matrices.

Unit IV: 12 hrs

Lattices And Boolean Algebra: Partial ordering – Posets – Lattices as posets – Properties of lattices - Lattices as algebraic systems – Sub lattices – Some special lattices – Fundamentals of Boolean algebra.

Reference books:

1. Discrete Mathematics and Its Applications, By Kenneth H. Rosen, McGraw Hill, Sept.2002.
2. Graph Theory with Applications to Engineering and Computer Science, Prentice Hall, Englewood Cliffs, 1974.
3. Combinatorics: Theory and Applications, By V. Krishnamurthy, East-West Press Pt. Ltd., New Delhi, 1986.
4. Discrete Mathematical Structures with Applications to Computer Science, By J. Tremble, Manohar, McGraw Hill Pub, 1975.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS212	NUMBER THEORY	SC	2	1	0	3	4

Course Objectives:

1. This course is concerned with the basics of analytical number theory.
2. Topics such as divisibility, congruence's, quadratic residues and functions of number theory are covered in this course.
3. Some of the applications of the said concepts are also included.

Course Outcome: The students can

1. Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization,
2. Solve linear Diophantine equations and congruences of various types, and use the theory of congruences in applications.
3. Prove and apply properties of multiplicative functions such as the Euler phi-function and of quadratic residues.
4. Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues,

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**2**	**2**	**2**	**1**	**1**		**1**	**3**	**3**	**3**
	CO2	**3**	**1**	**2**	**1**	**2**	**1**		**1**	**3**	**3**	**3**
	CO3	**3**	**2**	**2**	**1**	**2**		**1**	**1**	**3**	**3**	**3**
	CO4	**3**	**1**	**2**	**1**	**1**		**2**	**1**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	12
CO2	7.5		5	12.5	25	12
CO3		7.5	5	12.5	25	12
CO4		7.5	5	12.5	25	12
Total	15	15	20	50	100	48

Course Content: **Total Hours: 48 hrs**

Unit I: 12 hrs

Number theory - Congruences, residue classes, theorems of Fermat, Euler and Wilson, linear congruences, elementary arithmetical functions, primitive roots, quadratic residues and the law of quadratic reciprocity.

Unit II: 12 hrs

Prime numbers, The Fundamental theorem of Arithmetic, The series of Reciprocals of primes, The Euclidean Algorithm. Fermat and Mersenne numbers. Farey series, Farey dissection of the continuum, Irrational Numbers-Irrationality of mth root of N, e and π, Diophantine equations.

Unit III: 12 hrs

Arithmetical Functions – The Mobius function, The Euler' function and Sigma function, The Dirichlet product of Arithmetical functions, Multiplicative functions. Averages of Arithmetical functions – Euler summation formula, Some elementary asymptotic formulas, The average orders of $d(n)$, $\sigma(n)$, $\varphi(n)$, $\mu(n)$. Approximation Irrational numbers, Hurwitz's Theorem, Representation of a number by two or four squares.

Unit IV: 12 hrs

Continued fractions - Finite continued fractions, Convergent of a continued fraction, Continued fractions with positive quotients. Simple continued fractions, The representation of an irreducible rational fraction by a simple continued fraction. The continued fraction algorithm and Euclid's algorithm. The difference between the fraction and its convergents, Infinite simple continued fractions, the representation of an irrational number by an infinite continued fraction, Equivalent numbers and periodic continued fractions.

Reference Books:

1. D. M. Burton, Elementary number theory, McGraw Hill.
2. Hardy G. H. and Wright E. M., An Introduction to the Theory of Numbers (6th ed, Oxford University Press, (2008).
3. Niven, H. S., Zuckerman and H. L. Montgomery, An Introduction To The Theory Of Numbers, 5 th Edition, Wiley Student Editions
4. Apostol T. M., Introduction to Analytic number theory, UTM, Springer, (1976).

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS221	MACHINE LEARNING USING PYTHON	SC	1	1	2	4	6

Course Objective: The overall objectives of the course are:

1. Introduce the statistical foundations required for Machine Learning
2. Introduce advanced machine learning algorithms
3. To introduce participants to know the fundamentals of Python
4. To gain experience of doing independent study and research.

Course Outcomes: After completing the course, the student should be able to:

1. Perform all basic operations in the Dataset using the libraries.
2. Understand a wide variety of learning algorithms.
3. Understand how to evaluate models generated from data.
4. Develop an appreciation for what is involved in learning models from data.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	1		1			3	**3**	**3**	**3**
	CO2	3	2	1		1			3	**3**	**3**	**3**
	CO3	3	2	2		1			3	**3**	**3**	**3**
	CO4	3	2	1		1			3	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	18
CO2	7.5		5	12.5	25	18
CO3		7.5	5	12.5	25	18
CO4		7.5	5	12.5	25	18
Total	15	15	20	50	100	72

Course Content: **Total Hours: 72 hrs**

UNIT I: 18hrs

Introduction to Python: Features of Python - How to Run Python - Identifiers - Reserved Keywords - Variables - Comments in Python - Indentation in Python - Input, Output and Import Functions - Operators. **Data Types and Operations**: Numbers-Strings-List-Tuple-Set-Dictionary-Data type conversion, **Flow Control**: Decision Making-Loops-Nested Loops-Types of Loops. **Functions**: Function Definition-Function Calling - Function Arguments - Recursive Functions - Function with more than one return value.

UNIT 2: 18hrs

Components of learning – learning models – geometric models – probabilistic models – logic models – grouping and grading – learning versus design – types of learning – supervised – unsupervised – reinforcement – theory of learning – feasibility of learning – error and noise – training versus testing – theory of generalization – generalization bound – bias and variance – learning curve.

UNIT 3: 18hrs

Linear classification – univariate linear regression – multivariate linear regression – regularized regression – Logistic regression - Support vector machines - Distance Based Models: Nearest Neighbors Classification, Rule Based Models: Rule learning for Subgroup discovery, Association rule mining. Tree Based Models: Decision trees – learning decision trees – ranking and probability estimation trees – regression trees – clustering trees

UNIT 4: 18hrs

Clustering - K-Means Clustering - Hierarchical Clustering - Density-Based Clustering – Neural Network - perceptron – multilayer neural networks – learning neural networks structures- Reinforcement learning: Q-Learning -Deep Q-Network

Machine Learning Practical

1. Write a program to demonstrate how to handle the missing data in the dataset
2. Write a program to demonstrate Find S algorithm
3. Write a program to find the relation between the items in a dataset
4. Write a program to demonstrate the working of the decision tree based ID3 algorithm
5. Write a program to implement the naïve Bayesian classifier
6. Write a program to implement the Backpropagation algorithm
7. Write a program to implement k-Nearest Neighbour algorithm to classify the given dataset
8. Write a program to implement k-Means algorithm
9. Write a program to Locally Weighted Regression algorithm

Reference Books

1. Ethem Alpaydin - Introduction to Machine Learning, second edition, MIT Press, 2009,
2. Y. S. Abu-Mostafa, M. Magdon-Ismail, and H. T. Lin, ―Learning from Data, AML Book Publishers, 2012.
3. M. Mohri, A. Rostamizadeh, and A. Talwalkar, ―Foundations of Machine Learning‖, MIT Press, 2012.
4. Jeeva Jose and P. Sojan Lal, "Introduction to Computing and Problem Solving with PYTHON", Khanna Book Publising Co. (P) Ltd., 2016.
5. Wesley J. Chun, "Core Python Programming", Second Edition, Prentice Hall Publication, 2006.
6. Timothy A Budd, "Exploring Python", Tata McGraw Hill, New Delhi.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS222	STATISTICAL ANALYSIS SYSTEM (SAS)	SC	1	1	2	4	6

Course Objective: The overall objectives of the course are:

1. Perceive Analytics with **SAS**.
2. Describe the rules for the definition of SAS names.
3. Define the different datatypes, datasets in SAS.
4. Perform conditional and iterative looping into your **SAS** program.
5. Gain in-depth knowledge of integrating and refining datasets.
6. Run a simple SAS program.

Course Outcomes: After completing the course, the student should be able to:

5. Perform all basic operations in the Dataset using SAS libraries.
6. Understand a wide variety of learning algorithms in SAS.
7. Understand how to evaluate models generated from data.
8. Develop an appreciation for what is involved in learning models from data.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	1		1			3	**3**	**3**	**3**
	CO2	3	2	1		1			3	**3**	**3**	**3**
	CO3	3	2	2		1			3	**3**	**3**	**3**
	CO4	3	2	1		1			3	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**18**
CO2	**7.5**		**5**	**12.5**	**25**	**18**
CO3		**7.5**	**5**	**12.5**	**25**	**18**
CO4		**7.5**	**5**	**12.5**	**25**	**18**
Total	**15**	**15**	**20**	**50**	**100**	**72**

Course Content: **Total Hours: 72 hrs**

Unit I: 18 hrs

Introduction to the SAS System - Components of Base SAS Software - Output Produced by the SAS System - Ways to Run SAS Programs - Running Programs in the SAS Windowing Environment - Introduction to DATA Step Processing - The SAS Data Set- How the DATA Step Works - Supplying Information to Create a SAS Data Set - Introduction to Raw Data - Examine the Structure of the Raw Data: Factors to Consider - Reading Unaligned Data - Reading Data That Is Aligned in Columns - Reading Data That Requires Special Instructions - Reading Unaligned Data with More Flexibility - Mixing Styles of Input

Unit II: 18 hrs

Introduction to DATA Step Processing - Adding Information to a SAS Data Set - Defining Enough Storage Space for Variables - Conditionally Deleting an Observation - Working with Numeric Variables - Numeric Variables in SAS - Calculating with Numeric Variables - Comparing Numeric Variables - Storing Numeric Variables - Working with Character Variables - Identifying Character Variables and Expressing Character Values - Setting the Length of Character Variables - Handling Missing Values - Creating New Character Values - Saving Storage Space by Treating Numbers as Characters

Unit III: 18 hrs

Acting on Selected Observations - Selecting Observations - Constructing Conditions - Comparing Characters - Creating Subsets of Observations - Selecting Observations for a New SAS Data Set - Conditionally Writing Observations to One or More SAS Data Sets - Working with Grouped or Sorted Observations - Working with Grouped Data - Working with Sorted Data - Introduction to Using More Than One Observation in a Calculation - Accumulating a Total for an Entire Data Set - Obtaining a Total for Each BY Group - Writing to Separate Data Sets - Using a Value in a Later Observation

Unit IV: 18 hrs

Introduction to Shortcuts - Input File and SAS Data Set - Performing More Than One Action in an IF-THEN Statement - Performing the Same Action for a Series of Variables

- Introduction to Working with Dates- Understanding How SAS Handles Dates - Entering Dates - Displaying Dates - Using Dates in Calculations - Using SAS Date Functions - Comparing Durations and SAS Date Values - Introduction to Combining SAS Data Sets - Definition of Concatenating, Interleaving, Merging, Updating, Modifying - Comparing Modifying, Merging, and Updating Data Sets

Reference Books:

1. SAS Institute Step-by-Step Programming with Base SAS, illustrated Edison, 2001
1. Ron Cody, Learning SAS by Example: A Programmer's Guide, Second Edition, SAS Institute, 2018.
2. N. Jyoti Bass, K. Madhavi Lata & Kogent Solutions, Base Sas Programming Black Book,Dreamtech Press,2007

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNM201	Skill Development Program	MC	2	0	0	2	2

Note: The students will have to undergo Skill Development course being conducted by Training and Placement cell of the University

III SEMESTER

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0301	TOPOLOGY	HC	3	1	0	4	5

Course Objective: The overall objectives of the course are:

1. To explore the foundations of mathematics (logic and set theory) at a level and depth appropriate for someone aspiring to study higher-level mathematics and/or to become a professional mathematician.
2. To present an introduction to the field of topology, with emphasis on those aspects of the subject that are basic to higher mathematics.
3. To introduce the student to what it means to do mathematics, as opposed to learning about mathematics or to learning to do computational exercises.

Course Outcomes: **After completing the course, the student should be able to:**

1. Identify and apply the basic of Topology, The Metric Topology, and Interior Points.
2. Analyze different types of Topologies.
3. Analyze the Connectedness and compactness.
4. Analyze different Axioms and theorems by Urysohn's concepts and Tychonoff's results.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**2**	**1**	**1**	**2**		**1**		**3**	**3**	**3**
	CO2	**3**	**2**	**2**	**1**	**2**		**1**		**3**	**3**	**3**
	CO3	**3**	**2**	**1**		**1**		**1**		**3**	**3**	**3**
	CO4	**3**	**1**	**2**		**1**		**1**		**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

UNIT-I: 15 hrs

Basic Concepts , The Metric Topology, Interior Points, Limit Points, Boundary Points, Closure of a Set , Hausdorff Topological Spaces, Continuous Functions .

UNIT-II: 15hrs

Product Space, Connected Spaces , Connected Subsets of the Real Line, Some Properties of Connected Spaces, Connected Components

UNIT-III: 15 hrs

Compact Spaces and Related Results, Local Compactness , One Point Compactification of a Topological Space (X,J) , Tychonoff Theorem for Product Spaces

UNIT-IV: 15 hrs

First and Second Countable Topological Spaces , Properties of First Countable Topological Spaces , Regular and Normal Topological Spaces , Urysohn Lemma, Tietze Extension Theorem, Baire Category Theorem, Urysohn Metrization Theorem

Reference Books

1. J. R. Munkres, Topology, Second Edition, Prentice Hall of India, 2007.
2. Simmons G. F. Introduction to topology and modern analysis, Tata McGraw Hill, 1963.

3. Dugundji J. Topology, Prentice Hall of India, 1966.
4. Willard, General topology, Addison-Wesley, 1970.
5. Crump, W. Baker, Introduction to topology, Krieger Publishing Company, 1997.
6. Topology Without Tears by "SIDNEY A MORRIS', VERSION OF Feb 23, 2018.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0302	FUNCTIONAL ANALYSIS	HC	3	1	0	4	5

Course Objectives: The overall objectives of the course are:

1. To understand the concepts of linear transformation, isomorphism, normed linear space and Banach space.
2. To familiarize about open mapping theorem, closed graph theorem and uniform boundedness theorem.
3. To study the concepts of inner product, Hilbert spaces, Schwarz inequality, complete orthonormal sets.
4. To study the concepts of the adjoint, self-adjoint, normal and unitary operators, spectral theory.

Course Out comes: **After completing the course, the student should be able to:**

1. Analyse the concepts of linear space, normed linear space..
2. Analyse the concept of Banach space, open mapping theorem, closed graph theorem and uniform boundedness theorem.
3. Analyse the concepts of Hilbert spaces, Schwarz inequality, parallelogram law, Bessel inequality.
4. Analyse the concept of conjugate space, finite dimensional spectral theory.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	3	2	2		3	2	3	3	3
	CO2	3	2	3	2	1		2	1	3	3	3
	CO3	3	2	3	2	2		3		3	3	3
	CO4	3	2	3	2	1		2	1	3	3	3

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

Unit-I: 15 hrs

Linear Spaces, subspace and convex sets, Direct sum and Projections, the Holder and Minkowski inequalities. Normed linear spaces, Properties of norm, Quotient Norm and Quotient Map, Completeness of Normed Linear Spaces, Series in Normed Linear Spaces, Bounded, Totally Bounded, and Compact Subsets of a Normed Linear Space, Finite Dimensional Normed Linear Spaces, Separable Spaces and Schauder Bases.

Unit-II: 15 hrs

Hahn-Banach type theorems: The analytic form of Hahn-Banach, Geometric form of Hahn-Banach, The Baire Category theorem and its applications: The Baire Category theorem, Application I: The set of discontinuities of a limit of continuous Functions, Application II: Continuous but nowhere differentiable functions, Application III: The uniform boundedness principle, The Open Mapping and the Closed Graph, Weak Topologies. Reflexive Spaces. Separable Spaces. Uniform Convexity

Unit-III: 15 hrs

Inner products, Hilbert spaces, the dual space of a Hilbert space, Schwarz inequality, parallelogram law, orthogonal complements, orthonormal sets, Orthogonal Projection, Bessel's inequality, complete orthonormal sets, application of uniform boundedness Principle.

Unit-IV: 15 hrs

Banach Fixed Point Theorem, Riesz Representation theorem, the conjugate space, the adjoint of an operator, self-adjoint, normal and unitary operators, projections, finite dimensional spectral theory.

Reference Books:

1. W. Rudin, Functional analysis, 2nd ed., McGraw Hill, 2010.
2. G. F. Simmons, Introduction to topology and modern Analysis, Reprint, Tata McGraw-Hill, 2004.
3. K. Yoshida, Functional analysis, 6th ed., Springer, 1996.
4. E. Kreyszig, Introductory functional analysis with applications, 1st ed., John Wiley, 1978.
5. B. V. Limaye, Functional analysis, 2nd ed., New Age International, 1996.
6. S. Ponnusamy, Foundations of Funtional Analysis, Eight reprint, Narosa, 2014.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS301	OPERATIONS RESEARCH	SC	2	1	0	3	4

Course Objectives: **The overall objectives of the course are:**

1. To impart the knowledge of formulation of practical problems using the linear programming Method.
2. To impart the knowledge of solving LPP using simplex method, Big-M method.
3. To understand the concept of Duality in LPP and its advantages.
4. To learn about Integer programming problem and its applications.

Course Outcomes: After completing the course, the student should be able to:

1. Describe the basic concepts of convex analysis and explain the theoretical foundations of various issues related to linear programming modelling.
2. Formulate real-world problems as a linear programming model and describe the theoretical workings of the graphical and simplex method, demonstrate the solution process by hand and solver.
3. Explain the relationship between a linear program and its dual, including strong duality and complementary slackness.
4. Perform sensitivity analysis to identify the direction and magnitude of change of a linear programming model's optimal solution as the input data change.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	1	2	1	2		2	2	3	3	3
	CO2	3	1	2	2	1		1	2	3	3	3
	CO3	3	2	2	1	1		2	2	3	3	3
	CO4	3	2	2	1	1		2	2	3	3	3

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	12
CO2	7.5		5	12.5	25	12
CO3		7.5	5	12.5	25	12
CO4		7.5	5	12.5	25	12
Total	15	15	20	50	100	48

Course Content: **Total Hours: 48 hrs**

Unit-I: 12 hrs

Introduction to Operation Research(OR), History of OR, Stages of development of OR, OR tools and Techniques, applications of OR, Limitations of OR, Methodology of OR, computer software

for OR. Linear programming problem (LPP): Introduction, definitions, Graphical method of solving LPP.

Unit-II: 12 hrs

Simplex method- Introduction, Standard form of an LP problem, Simplex Algorithm (Maximization case and minimization case), Two-phase method, Big-M method, Revised simplex method.

Unit-III: 12 hrs

Duality in linear programming- Introduction, Formulation of dual linear programming problem, Advantages of duality.

Sensitivity analysis in linear programming-Introduction, sensitivity analysis-Change in objective function coefficient, Change in availability of resources, addition of new variable.

Unit-IV: Integer programming problem(IPP): 12 hrs

Introduction, Types of integer programming problem, Enumeration and cutting plane concept, Gomory's all integer cutting plane method, Gomory's mixed-integer cutting plane method, Branch and Bound method, Applications of zero-one integer programming.

REFERENCE BOOKS:

1. Kanti Swarup, P. K. Gupta, Man Mohan, Operations Research (15th Edn.), Sultan Chand & sons, New Delhi.
2. Hamdy A. Taha, Operations Research (7th Edn.), McGraw Hill Publications, New Delhi.2002.
3. Bazaara, Jarvis and Sherali, Linear Programming and Network Flows, 2th ed., John Wiley.
4. O. L. Mangasarian, Non Linear Programming, McGraw Hill, New York, 1979.
5. Mokther S. Bazaraa and C. M. Shetty, Non Linear Programming, Theory and Algorithms, Willy, New York, 1979.
6. Prem Kumar Gupta and D. S. Hira, Operations Research : An Introduction, S. Chand and Co., Ltd. New Delhi, 1983.
7. S. S. Rao, Optimization Theory and Applications, Wiley Eastern Limited, New Delhi, 1979.
8. G. Hadley, Linear Programming, Narosa Publishing House.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS302	MATHEMATICAL METHODS	SC	2	1	0	3	4

Weightage Distribution for Assessment

Course Objectives: The overall objectives of the course are:

1. The course will also develop an understanding of the elements of error analysis for numerical methods and certain proofs.
2. The course will further develop problem solving skills.
3. Derive appropriate numerical methods to solve a linear system of equations.

Course Outcomes: After completing the course, the student should be able to:

1. Apply various transforms to solve typical mathematical problems.
2. Apply the integral equations to solve IVP, BVP and eigen value problems.
3. Solve problems related with asymptotic expansions.
4. Analyse adapt regular, singular perturbation and irregular singular perturbation methods to solve differential equations.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
	CO1	3	3	2	1	2		2	1					3	3	3
	CO2	3	2	1	2	1		2	3					3	3	3
	CO3	3	2	1	1	2		1	1					3	3	3
	CO4	3	2	1	2	2		2	2					3	3	3

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	12
CO2	7.5		5	12.5	25	12
CO3		7.5	5	12.5	25	12
CO4		7.5	5	12.5	25	12
Total	15	15	20	50	100	48

Course Content: **Total Hours: 48 hrs**

Unit I: 12 hrs

Integral Transforms: General definition of Integral transforms, Kernels, etc. Development of Fourier integral, Fourier transforms – inversion, Illustration on the use of integral transforms, Laplace, Fourier, Hankel and Mellin transforms to solve ODEs and PDEs - typical examples. Discrete orthogonality and Discrete Fourier transform. Wavelets with examples, wavelet transforms.

Unit II: 12 hrs

Integral Equations: Definition, Volterra and Fredholm integral equations. Solution by separable kernel, Neumann's series resolvent kernel and transform methods, Convergence for Fredholm and Volterra types. Reduction of IVPs BVPs and eigenvalue problems to integral equations. Hilbert Schmidt theorem, Raleigh Ritz and Galerkin methods.

Unit III: 12 hrs

Asymptotic expansions : Asymptotic expansion of functions, power series as asymptotic series, Asymptotic forms for large and small variables. Uniqueness properties and Operations. Asymptotic expansions of integrals; Method of integration by parts (include examples where the method fails), Laplaces method and Watson's lemma, method of stationary phase and steepest descent.

Unit IV: 12 hrs

Regular and singular perturbation methods: Parameter and co-ordinate perturbations. Regular perturbation solution of first and second order differential equations involving constant and

variable coefficients. Include Duffings equation, Vanderpol oscillator, small Reynolds number flow. Singular perturbation problems, Matched asymptotic expansions, simple examples. Linear equation with variable coefficients and nonlinear BVP's. Problems involving Boundary layers. Poincare – Lindstedt method periodic solution. WKB method, turning points, zeroth order Bessel function for large arguments, solution about irregular singular points.

REFERENCE BOOKS:

1. I. N. Sneddon – The use of Integral Transforms, Tata Mc Graw Hill, New Delhi, 1974.
2. R. P. Kanwal: Linear integral equations theory and techniques, Academic Press, New York, 1971.
3. C. M. Bender and S.A. Orszag – Advanced mathematical methods for scientists and engineers, Mc Graw Hill, New York, 1978.
4. H. T. Davis – Introduction to nonlinear differential and integral equations, Dover Publications, 1962.
5. A. H. Nayfeh – Perturbation Methods, John Wiley & sons New York, 1973.
6. Don Hong, J. Wang and R. Gardner. Real analysis with introduction to wavelets and applications, Academic Press Elsevier (2006).

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNON01	MOOC / SWAYAM/ INTENSHIP	SC	4	0	0	4	4

MOOC/ SWAYAM:

Globally, MOOC (Massive Open Online Course) platforms are gaining much popularity. Considering the popularity and relevance of MOOCs, Government of India has also launched an indigenous platform, SWAYAM. SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) is basically an integrated MOOCs platform for distance education that is aimed at offering all the courses from school level (Class IX) to post-graduation level. The platform has been developed collaboratively by MHRD (Ministry of Human Resource Development) and AICTE

(All India Council for Technical Education) with the help of Microsoft and is capable of hosting 2,000 courses.

There are many other international agencies, foreign universities offering OOC courses. A student shall register and successfully complete any of the courses available on SWAYAM. Student shall inform the MOOC/SWAYAM coordinator of the school about the course to which he/she has enrolled. The minimum duration of the course shall be not less than 40 hours and of 4 credits. The student should submit the certificate issued by the SWAYAM to the MOOC/SWAYAM coordinator of the school, the grades obtained in the course shall be forwarded to concerned authority of the University

Internship:

The students shall have to undergo internship of the minimum duration fixed by the university and as per the guidelines of the University either in industry or in a business sector, R&D organization, including educational institutes with excellent research culture. The students are expected to submit a formal report at the end of the internship programme. The marks for internship shall be awarded based on the (a) presentation and (b) comprehensive viva, by the panel of examiners constituted by the School.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNM301	SOFT SKILLS	MC	2	0	0	2	2

Note: The students will have to undergo Soft Skill Training being conducted by Training and Placement cell of the University

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNO301	OPTIMIZATION TECHNIQUES	OE	3	1	0	4	5

Course Objectives: The overall objectives of the course are:

1. To learn the geometry and standard form of linear programming problems
2. To learn various methods of non-linear programming to compute structural engineering problems.
3. To learn geometric and dynamic programming
4. To formulate and obtain the solution of structural optimization problems by different techniques.

Course Outcomes: **After completing the course, the student should be able to:**

1. Apply the engineering applications and formulation of optimization problems
2. Analyze various optimization techniques and the geometry and standard form of linear programming problems
3. Apply various methods of non-linear programming to compute structural engineering problems and Geometric and dynamic programming
4. Formulate and apply the solution of structural optimization problems by different techniques.

Mapping of Course Outcomes with Program Outcomes

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**2**	**2**	**2**			**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**1**	**1**	**2**	**2**		**1**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**	**2**	**1**		**2**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**	**2**	**1**		**1**	**2**	**3**	**3**	**3**

Weightage Distribution for Assessment

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**15**
CO2	**7.5**		**5**	**12.5**	**25**	**15**
CO3		**7.5**	**5**	**12.5**	**25**	**15**
CO4		**7.5**	**5**	**12.5**	**25**	**15**
Total	**15**	**15**	**20**	**50**	**100**	**60**

Course Content: **Total Hours: 60 hrs**

Unit 1: **15 hrs**

Introduction: Introduction to optimization, engineering applications of optimization, Formulation of structural optimization problems as programming problems. Optimization Techniques: Classical optimization techniques, single variable optimization, multivariable optimization with no constraints, unconstrained minimization techniques and algorithms constrained optimization solutions by penalty function techniques, Lagrange multipliers techniques and feasibility techniques.

Unit 2: 15 hrs

Linear Programming: Linear programming, standard form of linear programming, geometry of linear programming problems, solution of a system of linear simultaneous equations, pivotal production of general systems of equations, simplex algorithms, revised simpler methods, duality in linear programming.

Unit 3: 15 hrs

Non-linear programming: Non-linear programming, one dimensional minimization methods, elimination methods, Fibonacci method, golden section method, interpolation methods, quadratic and cubic methods, Unconstrained optimization methods, direct search methods, random search methods, descent methods. Constrained optimization techniques such as direct methods, the complex methods, cutting plane method, exterior penalty function methods for structural engineering problems.

Unit 4: 15 hrs

Game Theory: The formulation of two persons, zero sum games, solving simple games- a prototype Example, games with mixed strategies, graphical solution procedure, and dominance rule, odd's method.

Sequencing Problems: Introduction, Definition, n-Jobs through 2-Machines, n-Jobs through 3-Machines, n-Jobs through k- Machines, 2-Jobs through k-Machines.

Structural Optimization and Geometric programming: Geometric programming, conversion of NLP as a sequence of LP/ geometric programming.

Reference Books:

1. S. S Rao, "Optimization – Theory and Practice" – Wiley Eastern Ltd.
2. Uri Krisch, "Optimum Structural Design" – McGraw Hill.
3. Richard Bronson, "Operation Research" – Schaum's Outline Series.
4. Bhavikatti S. S, "Structural Optimization using sequential linear Programming" – Vikas Publishing House.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNO302	CRYPTOGRAPHY	OE	3	1	0	4	5

Course Objectives: The overall objectives of the course are:

1. To understand the concepts of public key encryption and number theory
2. To understand authentication and Hash functions.
3. To know the network security tools and applications.
4. To understand the system level security used.

Course Outcomes: After completing the course, the student should be able to:

1. Analyse the principles and practices of cryptographic techniques and the theory of fundamental cryptography, encryption, and decryption algorithms.
2. Analyse generic security threats and vulnerabilities and identify and analyse particular security problems for a given application.
3. Model simple cryptosystems by applying encryption algorithms.
4. Comprehend secure identity management (authentication), message authentication, and digital signature techniques.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**2**	**1**		**1**		**2**	**2**	**3**	**3**	**3**

	CO2	**3**	**2**	**1**	**1**	**1**		**2**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**	**2**	**1**		**1**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**1**	**2**	**1**		**2**	**1**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	**IA1**	**IA2**	**Assignment**	**SEE**	**Total**	**Hours**
CO1	**7.5**		**5**	**12.5**	**25**	**15**
CO2	**7.5**		**5**	**12.5**	**25**	**15**
CO3		**7.5**	**5**	**12.5**	**25**	**15**
CO4		**7.5**	**5**	**12.5**	**25**	**15**
Total	**15**	**15**	**20**	**50**	**100**	**60**

Course Content: **Total Hours: 52 hrs**

Unit-I 15hrs

OSI Security Architecture - Classical Encryption techniques – Cipher Principles – Data Encryption Standard – Block Cipher Design Principles and Modes of Operation - Evaluation criteria for AES – AES Cipher – Triple DES – Placement of Encryption Function – Traffic Confidentiality

Unit-II: 15hrs

Key Management - Diffie-Hellman key Exchange – Elliptic Curve Architecture and Cryptography - Introduction to Number Theory – Confidentiality using Symmetric Encryption – Public Key Cryptography and RSA.

Unit-III: 15hrs

Authentication requirements – Authentication functions – Message Authentication Codes – Hash Functions – Security of Hash Functions and MACs – MD5 message Digest algorithm - Secure Hash Algorithm – RIPEMD – HMAC Digital Signatures – Authentication Protocols – Digital Signature Standard

Unit-IV: 15hrs

Intrusion detection – password management – Viruses and related Threats – Virus Counter measures – Firewall Design Principles – Trusted Systems.

Reference Books:

1. William Stallings, "Cryptography And Network Security – Principles and Practices", Pearson Education, 2011.
2. Atul Kahate, "Cryptography and Network Security", Tata McGraw-Hill, 2003.
3. Bruce Schneier, "Applied Cryptography", John Wiley & Sons Inc, 2001.
4. Charles B. Pfleeger, Shari Lawrence Pfleeger, "Security in Computing", Third Edition, Pearson Education, 2003.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0303	Dissertation Phase -1	HC	0	0	2	2	4

IV SEMESTER

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0401	NUMERICAL ANALYSIS	HC	3	1	0	4	5

Course Objective: The overall objectives of the course are:

1. The course will also develop an understanding of the elements of error analysis for numerical methods and certain proofs.
2. The course will further develop problem solving skills.
3. Derive appropriate numerical methods to solve a linear system of equations.

Course outcome: After completing the course, the student should be able to:

1. Apply different numerical techniques, solve the non-linear equations in one variab
2. Analyze the different types of interpolation methods
3. Analyze various numerical methods and solve ODE
4. Solve partial differential equations using various numerical methods.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**2**	**2**	**1**			**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**	**1**	**1**			**1**	**3**	**3**	**3**
	CO3	**3**	**2**	**2**		**2**		**1**	**1**	**3**	**3**	**3**
	CO4	**3**	**1**	**1**	**2**			**1**	**1**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

Unit-1: 15 Hrs

Fixed point iterative method - convergence and acceleration by Aitken's Δ^2 -process. Newton-Raphson methods for multiple roots and their rate of convergence criteria, Bairstow's method. Solution of system of equations: Gauss-elimination with pivotal strategy. Factorization methods (Crout's, Doolittle and Cholesky). Tri-diagonal systems-Thomas algorithm. Iterative methods: Matrix norms, error analysis and ill-conditioned systems

Unit-2: 15 Hrs

Review of interpolations basics, Lagrange, Hermite methods and error analyses. Numerical integration: Review of integrations- Newton Cote's formula, Gaussian quadrature - Gauss-Legendre, Gauss-Chebyshev, Gauss-Lagaurre, Gauss-Hermite and error analyses, Spline interpolation.

Unit-3: 15 Hrs

Numerical solution of first order ordinary differential equations: Initial value problems: Picard's, Euler's and Modified Euler's methods, Runge-Kutta methods of fourth order, Predictor and corrector method. Numerical solution of simultaneous ordinary differential equations: Picard's, Euler's and Modified Euler's methods, Runge-Kutta methods of fourth order. Numerical solution of second order ordinary differential equations: Picard's, Runge-Kutta methods of fourth order, Milnes's predictor and corrector method.

Unit 4: 15 Hrs

Numerical solution of partial differential equations: Elliptic equations: Difference schemes for Laplace and Poisson's equations. Parabolic equations: Difference methods for one-dimension–

methods of Schmidt. Hyperbolic equations: Difference methods for one-dimension- explicit and implicit schemes.

REFERENCE BOOKS

1. M. K. Jain: Numerical solution of differential equations, Wiley Eastern (1979), Second Edition.

2. C. F. Gerald and P. O. Wheatley : Applied Numerical Methods, Low- priced edition, Pearson Education Asia (2002), Sixth Edition.

3. D. V. Griffiths and I.M. Smith, Numerical Methods for Engineers, Blackwell Scientific Publications (1991).

4. S. C. Chapra, and P. C. Raymond: Numerical Methods for Engineers, Tata Mc Graw Hill, New Delhi (2000)26.

5. R. L. Burden, and J. Douglas Faires: Numerical Analysis, P.W.S. Kent Publishing Company, Boston (1989), Fourth edition.
6. S. S. Sastry : Introductory methods of Numerical analysis, Prentice- Hall of India, New Delhi (1998).
7. M. K. Jain, S. R. K. Iyengar and R. K. Jain : Numerical methods for scientific and Engineering computation, Wiley Eastern (1993)

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS411	DIFFERENTIAL GEOMETRY	SC	2	1	0	3	4

Course Objectives: The overall objectives of the course are:

1. To understand the basic concepts of calculus on Euclidean space.
2. To familiarize with frame fields, covariant derivatives, isometries of E^3.
3. To familiarize with calculus on surfaces.
4. To familiarize with shape operators.

Course Outcomes: **After completing the course, the student should be able to:**

1. Apply the concepts of vector fields, directional derivatives, differential forms, derivative map.
2. Apply the concepts of Frenet apparatus, covariant derivatives, and isometries.
3. Explain the calculus on surfaces.
4. Apply the computational techniques for the Normal, Gaussian, and Mean curvatures.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**			**1**			**3**	**3**	**3**
	CO3	**3**	**2**	**2**	**1**	**2**		**2**	**1**	**3**	**3**	**3**
	CO4	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	**7.5**		**5**	**12.5**	**25**	**12**
CO2	**7.5**		**5**	**12.5**	**25**	**12**
CO3		**7.5**	**5**	**12.5**	**25**	**12**
CO4		**7.5**	**5**	**12.5**	**25**	**12**
Total	**15**	**15**	**20**	**50**	**100**	**48**

Course Content: **Total Hours: 48 hrs**

Unit I: 12 hrs

Calculus on Euclidean Space: Euclidean space, Natural coordinate functions, Differentiable functions, Tangent vectors and tangent spaces, Vector fields, Directional derivatives and their properties, Curves in E3, Velocity and speed of a curve, Reparametrization of a curve, 1-forms and Differential forms, Wedge product of forms, Mappings of Euclidean spaces, Derivative map.

Unit II: 12 hrs

Frame Fields: Arc length parametrization of curves, Vector field along a curve, Tangent vector field, Normal vector field and Binormal vector field, Curvature and torsion of a curve, The Frenet formulas, Frenet approximation of unit speed curve and Geometrical interpretation, Properties of plane curves and spherical curves, Arbitrary speed curves, Cylindrical helix Covariant derivatives and covariant differentials, Cylindrical and spherical frame fields, Connection forms, Attitude matrix, Structural equations, Isometries of E3 - Translation, Rotation and Orthogonal transformation, The derivative map of an isometry.

Unit III: 12 hrs

Calculus on a Surface: Coordinate patch, Monge patch, Surface in E3, Special surfaces- sphere, cylinder and surface of revolution, Parameter curves, velocity vectors of parameter curves, Patch computation, Parametrization of surfaces- cylinder, surface of revolution, Tangent vectors, vector fields and curves on a surface in E3, Directional derivative of a function on a surface of E3, Differential forms and exterior derivative of forms on surface of E3, Pull back functions on surfaces of E3.

Unit IV: 12 hrs

Shape Operators: Definition of shape operator, Shape operators of sphere, plane, cylinder and saddle surface, Normal curvature, Normal section, Principal curvature and principal direction, Umbilic points of a surface in E3, Euler's formula for normal curvature of a surface in E3, Gaussian curvature, Mean curvature and Computational techniques for these curvatures, Minimal surfaces, Special curves in a surface of E3 - Principal curve, geodesic curve and asymptotic curves.

REFERENCE BOOKS:

1) Barrett O' Neil: Elementary Differential Geometry. Academic Press, New York and London, 1966.

2) T. J. Willmore: An introduction to Differential Geometry. Clarendon Press, Oxford 1959.

3) D. J. Struik: Lectures on Classical Differential Geometry, Addison Wesley, Reading, Massachusetts, 1961.

Nirmala Prakassh: Differential Geometry- an integrated approach. Tata McGraw-Hill, New Delhi, 1981.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS412	FINITE ELEMENT METHOD	SC	2	1	0	3	4

Course Objectives: The overall objectives of the course are:

1. Illustrate about different finite element methods in one, two and three dimensions.
2. Analyse variety of finite elements as per the requirements of solutions of differential equations.

Course Outcome: After completing the course, the student should be able to:

1. Apply finite element method to solve Differential equations.
2. Apply finite element method to solve heat transfer problems.
3. Apply finite element method to solve two- and three-dimensional problems.
4. Apply finite element method to analyse Laplace &Poisson equations for specific applications.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**3**	**3**
	CO2	**3**	**2**	**1**		**1**	**1**			**3**	**3**	**3**
	CO3	**2**	**3**	**2**	**1**	**1**		**2**	**1**	**3**	**3**	**3**
	CO4	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	12
CO2	7.5		5	12.5	25	12
CO3		7.5	5	12.5	25	12
CO4		7.5	5	12.5	25	12
Total	15	15	20	50	100	48

Course Content: **Total Hours: 48 hrs**

Unit I: 12hrs

Weighted Residual Approximations: Point collocation, Galerkin and Least Squares method. Use of trial functions to the solution of differential equations.

Unit II: 12 hrs

Finite Elements: One dimensional and two-dimensional basis functions, Lagrange and serendipity family elements for quadrilaterals and triangular shapes. Isoparametric coordinate transformation. Area coordinates standard 2- squares and unit triangles in natural coordinates.

Unit III: 12 hrs

Finite Element Procedures: Finite Element Formulations for the solutions of ordinary and partial differential equations: Calculation of element matrices, assembly, and solution of linear equations.

Unit IV: 12 hrs

Finite Element solution of one dimensional ordinary differential equations, Laplace and Poisson equations over rectangular and nonrectangular and curved domains. Applications to some problems in linear elasticity: Torsion of shafts of a square, elliptic and triangular cross sections.

Reference Books:

1. O. C. Zienkiewiez and K. Morgan : Finite Elements and approximation, John Wieley, 1983
2. P. E. Lewis and J. P. Ward : The Finite element method- Principles and applications, Addison Weley, 1991
3. L. J. Segerlind : Applied finite element analysis (2nd Edition), John Wiley, 1984
4. O. C. Zienkiewicz, R. L. Taylor: The FEM. Vol.1 Basic formulation and Linear problems, 4Ed, NY, MGH, 1989.
5. J. N. Reddy: An introduction to finite element method, New York, Mc.Graw Hill, 1984.
6. D. W. Pepper, J. C. Heinrich: The finite element method, Basic concepts and applications, Hemisphere, Publishing Corporation, Washington, 1992.
7. S. S. Rao: The finite element method in Engineering, 2nd Edition, Oxford, Pergamon Press, 1989.
8. D. V. Hutton, fundamental of Finite Element Analysis, (2004).
9. E. G. Thomson, Introduction to FEM, Theory Programming and applications, Wiley Student Ed, (2005).

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0403	CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS	HC	3	1	0	4	5

Course Objective: The overall objectives of the course are:

1. To understand the concept of integral equations.
2. To understand and solve the applications related problems such as classical mechanics and differential equations.

Course Outcome: After completing the course, the student should be able to:

1. Apply the Euler's equation to solve geodesics and Brachistochrone problem with boundary conditions.

2. Analyse different types of advanced variational problems.
3. Analyze the concepts of linear integral equations with applications.
4. Apply different methods of solution of linear integral equations.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	1	2	2	1		1	1	3	3	3
	CO2	3	2	1	2	2		2	2	3	3	3
	CO3	3	2	2	2	2		1	2	3	3	3
	CO4	3	2	1	2	2		1	2	3	3	3

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	15
CO2	7.5		5	12.5	25	15
CO3		7.5	5	12.5	25	15
CO4		7.5	5	12.5	25	15
Total	15	15	20	50	100	60

Course Content: **Total Hours: 60 hrs**

Unit-I 15hrs

Euler equations and variational notations: Maxima and minima, method of Lagrange multipliers, the simplest case, Euler equation, extremals, stationary function, geodesics, Brachistochrone problem, natural boundary conditions and transition conditions, variational notation, the more general case.

Unit-II 15hrs

Advanced variational problems: Constraints and Lagrange multipliers, variable end points, Sturm- Liouville problems, Hamilton's principle, Lagrange's equation, theRayleigh-Ritz method.

Unit-III 15hrs

Linear integral equations: Definitions, integral equation, Fredholm and Volterra equations, kernel of the integral equation, integral equations of different kinds,relations between differential and integral equations, symmetric kernels, the Green's function.

Unit-IV 15hrs

Methods for solutions of linear integral equations: Fredholm equations with separable kernels, homogeneous integral equations, characteristic values and characteristic functions of integral equations, Hilbert-Schmidt theory, iterative methods for solving integral equations of the second kind, the Neumann series.

Reference Books:

1. F. B. Hildebrand, Methods of Applied Mathematics, New York:Dover, 1992.
2. B. Dacorogna, Introduction to the Calculus of Variations, London: Imperial College Press, 2004.
3. F. Wan, Introduction to the Calculus of Variations and Its Applications, New York: Chapman/Hall, 1995.
4. J. Jost and X. Li-Jost, Calculus of Variations, Cambridge: Cambridge University Press, 1998.
5. R. P. Kanwal, Linear Integral Equations: Theory and Techniques, New York: Birkhäuser, 2013.
6. C. Corduneanu, Integral Equations and Applications, Cambridge: Cambridge University Press, 2008.
7. A. J. Jerry, Introduction to Integral Equations with Applications, 2nd ed., New York, John Wiley & Sons, 1999.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS421	FUZZY SET THEORY AND APPLICATIONS	SC	2	1	0	3	4

Course Objectives: The overall objectives of the course are:

1. Students will study the fuzzy sets, basic operation on fuzzy sets, inverse and image fuzzy operations.
2. Students will study fuzzy relation and fuzzy graph.
3. Student will read and analyse the fuzzy sets and fuzzy logic on possibility theory and probability theory.

Course Outcomes: After completing the course, the student should be able to:

1. Analyze the concept of fuzzy set and fuzzy logic using fuzzy operations.
2. Apply the fuzzy operations on functions, relations and fuzzy graph.
3. Analyze possibility theory, fuzzy measure and possibility theory verses probability theory.
4. Apply the operation of fuzzy sets on fuzzy reasoning, fuzzy system and pattern recognition.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	**3**	**2**	**2**	**1**	**2**		**1**	**2**	**3**	**3**	**3**
	CO2	**3**	**2**	**2**	**1**	**1**		**1**	**2**	**3**	**3**	**3**
	CO3	**3**	**2**	**1**	**2**	**1**		**1**	**2**	**3**	**3**	**3**
	CO4	**3**	**2**	**2**	**1**	**2**		**2**	**2**	**3**	**3**	**3**

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	12
CO2	7.5		5	12.5	25	12
CO3		7.5	5	12.5	25	12
CO4		7.5	5	12.5	25	12
Total	15	15	20	50	100	48

Course Content: **Total Hours: 48 hrs**

Unit I: 12 hrs

Crisp sets and Fuzzy sets - Introduction, crisp sets an overview, the notion of fuzzy sets basic concepts of fuzzy sets, membership functions, methods of generating membership functions, defuzzification methods- operations on fuzzy sets - fuzzy complement, fuzzy union, fuzzy intersection, combinations of operations, general aggregation operations.

Unit II: 12 hrs

Fuzzy arithmetic and Fuzzy relations: Fuzzy numbers- arithmetic operations on intervals- arithmetic operations on fuzzy numbers- fuzzy equations, Fuzzy relations : binary relations, binary relations on a single set, equivalence and similarity relations, compatibility or tolerance relations.

Unit III: 12 hrs

Fuzzy measures, belief and plausibility measures, probability measures, possibility and necessity measures, possibility distribution - relationship among classes of fuzzy measures.

Unit IV: 12 hrs

Fuzzy Logic and Applications: Classical logic : an overview, fuzzy logic, approximate reasoning - other forms of implication operations - other forms of the composition operations, fuzzy decision making fuzzy logic in database and information systems - fuzzy pattern recognition, fuzzy control systems, fuzzy optimization.

References:

1. G. J. Klir & T. A. Folger , Fuzzy sets, Uncertainty and Information, Prentice Hall of India, 1988.
2. H. J. Zimmerman, Fuzzy Set theory and its Applications, Kluwer Academic Publishers, 4nd Edn., 2001.
3. G. J. Klir & B. Yuan, Fuzzy sets and Fuzzy logic: Theory and Applications, Prentice Hall of India, 1997.
4. H. T. Nguyen & E. A. Walker, First Course in Fuzzy Logic, Chapman & Hall, 2nd Edn., 1999.
5. J. M. Mendel, Uncertain Rule, Based Fuzzy Logic Systems ; Introduction and New Directions, PH PTR, 2000.
6. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill, 1997.
7. J. J. Buckley, E. Eslami , An Introduction to Fuzzy logic and Fuzzy sets, Springer , 2002

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SNS422	ADVANCED GRAPH THEORY	SC	2	1	0	3	4

Course Objectives: **The overall objectives of the course are:**

1. Analyze the idea of traversability
2. Utilize line graphs in Applications
3. Make use of the Techniques of factorization & colorablity
4. Discover the relation between graphs and matrices.

Course Outcome: After completing the course, the student should be able to

1. Analyze the concept of traversability by using matching to estimate the bond lengths and to solve TSP.
2. Construct connectivity for solving utility problems, mapping problems using line graphs.
3. Identify the concept of colorability to solve problems like Sudoku
4. Discover the Application of graphs using mobile frequency assignment problems.

Mapping of Course Outcomes with Program Outcomes:

Course Code	POS/ COs	PO1	PO2	PO3	PO4	PO5	PO6	P7	PO8	PSO1	PSO2	PSO3
	CO1	3	2	2	1	1	1	1	1	3	3	3
	CO2	3	2	1			1			3	3	3
	CO3	3	2	2	1	2		2	1	3	3	3
	CO4	3	2	2	2	1	1	1	2	3	3	3

Weightage Distribution for Assessment:

COs	IA1	IA2	Assignment	SEE	Total	Hours
CO1	7.5		5	12.5	25	12
CO2	7.5		5	12.5	25	12
CO3		7.5	5	12.5	25	12
CO4		7.5	5	12.5	25	12
Total	15	15	20	50	100	48

Course Content: **Total Hours: 48 hrs**

Unit I: 12 Hrs

Definition and Some properties of line graphs, Characterization of line graphs, Line graphs and traversability

Unit II 12Hrs

Matrices – The adjacency matrix The incidence matrix, The cycle matrix , the Eigen Values and its applications in Networking

Unit III: 12 Hrs

Distances in graphs and its applications, Distance matrix, Characteristic polynomial and Distance Eigen Values and its applications in Communication

Unit IV: 12Hrs

Definition of Domination, types of Domination , Domination numbers -Some elementary properties and its applications in facility location problems.

Reference Books

1. F. Harary – Graph Theory, Addition Wesley Reading Mass, 1969
2. N. Deo – Graph Theory With Applications to Engineering and Computer Science, Prentice
3. K. R. Parthasarathy – Basic Graph Theory, Tata McGraw-Hill, New Delhi, 1994
4. G. Chartand and L. Lesniak – Graphs and Diagraphs, Qwadsworth and Brooks, 2nd Ed
5. Clark and D. A. Holton – A First Look at Graph Theory, Allied publishers
6. D. B. West – Introduction to Graph Theory, Pearson Education Inc., 2001, 2nd Ed.
7. J. A. Bondy and U. S. R. Murthy – Graph Theory with applications, Elsevier, 1976
8. V. R. Kulli, Domination Theory, Vishwa International Publications, 2012.

Course Code	Course Title	Course Type	L	T	P	C	Hrs./ Wk.
M21SN0403	Dissertation Phase -2	HC	0	0	4	5	4

Career Opportunities

Having a degree or P.G. Degree will open doors to the world of opportunities for you. But Employers are looking for much more than just a degree. They want graduates who stand out from the crowd and exhibit real life skills that can be applied to their organizations. Examples of such popular skills employers look for include:

- Willingness to learn
- Self motivation
- Team work
- Communication skills and application of these skills to real scenarios
- Requirement of gathering, design and analysis, development and testing skills
- Analytical and Technical skills
- Computer skills
- Internet searching skills
- Information consolidation and presentation skills
- Role play
- Group discussion, and so on

The REVA University therefore, has given utmost importance to develop these skills through variety of training programs and such other activities that induce the said skills among all students. A full-fledged Career Counseling, Training and Placement (CCTP) Centre headed by well experienced dynamic Trainer, Counselor and Placement Officer supported by an efficient team does handle all aspects of Internships and Placement for the students of REVA University. The prime objective of the CCTP Centre is to liaison between REVA graduating students and industries by providing a common platform where the prospective employer companies can identify suitable candidates for placement in their respective organization. The CCTP Centre organizes pre-placement training by professionals and also arranges expert talks to our students. It facilitates students to career guidance and improve their employability. In addition, CCTP Centre forms teams to perform mock interviews. It makes you to enjoy working with such teams and learn many things apart from working together in a team. It also makes you to participate in various student clubs which helps in developing team culture, variety of job skills and overall personality.

The need of the hour in the field of Engineering is efficient leaders of repute, who can deal the real time problems with a flavour of innovation. This kept in focus, the Training and Placement cell has designed the training process, which will commence from second semester along with the curriculum. Special coaching in personality development, career building, English proficiency, reasoning, puzzles, leadership, and strategic management and communication skills

to every student of REVA University is given with utmost care. The process involves continuous training and monitoring the students to develop their soft skills including interpersonal skills that will fetch them a job of repute in the area of his/her interest and march forward to make better career.

Skill development is one of the very important activities of the University and Industry relationship.
A skill development centre is established to organize skill and certification programs. The students shall compulsorily complete at-least two skill/certification based programs before the completion of the degree.

The University has collaborations with Industries, Corporate training organizations, research institutions and Government agencies like NSDC (National Skill Development Corporation) to conduct certification programs.

The various skill/certification programs identified are as follows.

- Big-data and Cloud Computing, Internet of Things (IOT), ORACLE, MYSQL, Advanced Java and Internals of LINUX/UNIX
- Red-hat certified programs on LINUX,
- Management related programs like SAP,ERP and Business Analytics
- Open Source software/hardware, Software Testing
- Advanced networking based CISCO / Microsoft technology.
- Web designing, System administration
- IBM certified programs.

The University has signed MOU's with Multi-National Companies, research institutions, Government agencies like NSDC (National Skill Development Corporation) and universities abroad to facilitate greater opportunities of employability, students' exchange programs for higher learning and for conducting certification programs.

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